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European Hydro-Electric Power Development

By Charles H. Mitchell,
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Recognizing that America's wealth in water power is an asset to be seized upon and developed to the utmost according to the expansion of the country, it is but natural that engineers have diligently turned their attention to this branch of engineering. In following this opportunity, or rather necessity, American engineers (and by American I include Canadian engineers), while evolving their own principles of design and construction, naturally seek much inspiration abroad, especially in those countries which, historically at least, have led in this branch of work. Notwithstanding the many conditions peculiar to America, and especially of the northern portion, such as climate and labor as well as of industry and commerce generally, the basic conditions and principles of the design, construction and operation of hydro-electric power plants, are much the same as in Europe.

Viewed from the hydro-electric standpoint of engineering, Central Europe undoubtedly has led all other portions of the world and it is there the engineer must go, even today, for many of his best ideas, which ideas, in practice and precedent, are in many cases as far ahead of those of America as are the European fashions.

It is not the least surprising that Switzerland, Northern Italy, Eastern France and the Austrian Tyrol should have attained this distinction, because they have grown into it by sheer necessity. These regions do not contain a pound of coal or other fuel in quantity, and it was to be expected that to the glacier-fed streams and waterfalls the manufacturer and engineer would turn for their power. The result of this has been the gradual development of the hydraulic turbine, the increase of its efficiency and the introduction and adoption of ingenious methods of application and control of water. And when electrical transmission became a settled factor, these countries were quick to seize upon its advantages in conjunction with their hydraulic works, with the result that in many respects they are, and continue to be, several years ahead of their competitors.

While through such evolution the excellence of design and construction of the hydraulic portions of hydro-electric equipments have attained an eminence in European practice which is still far ahead of most American practice, the conditions on the electrical side are reversed, in the writer's opinion, and it seems to be generally admitted that American design and construction are in the front. There are, however, many points in the European systems with which engineers on the American side of the water

might do well to familiarize themselves. Among these might be noted the wide power distribution features, the great attention to detail, both technical and commercial, the very general use of small motors in what, in most cases, are almost household industries, and the popular education which has been directed by the government and power companies in cooking to the more universal use of electric power.

To present in such limited space any adequate description of typical installations in the several countries in Central Europe would be well nigh impossible, and it is the purpose of this paper to rather indicate some of the interesting features, both hydraulic, mechanical and electrical, in a few of the more important and recent plants. All of these plants have been visited and studied within recent years by the writer and the following short descriptions and comments are based upon personal observation and the illustrations are from private photographs.

With all the installations indicated there is indeed a great similarity in many of the electrical features, more especially because it is only very recently that long distance, high tension transmission, as we know it in this country, has been attempted. On the hydraulic side, there is considerable dissimilarity, and on this account the many installations naturally fall into several distinct classes. The simplest division is with relation to the hydraulic operating conditions, which for convenience have been divided into low, medium and high heads.

Low Head Plants

Low head plants, as now designed in Europe, are not comparable with those of 20 or even 10 years ago, nor with the practice still prevailing in America. Water, the invaluable asset, is too precious to the European to allow any waste, such as even now is common in plants on this side of the ocean. To deal with such large quantities of water as are involved in low head propositions has required bold design and bolder financing to obtain every foot-pound of energy throughout the year. Nowhere have more ingenious devices been employed to meet abnormal fluctuations in the level of head and tail water under low heads than in Switzerland, and from an hydraulic point of view this is the leading feature in the following.

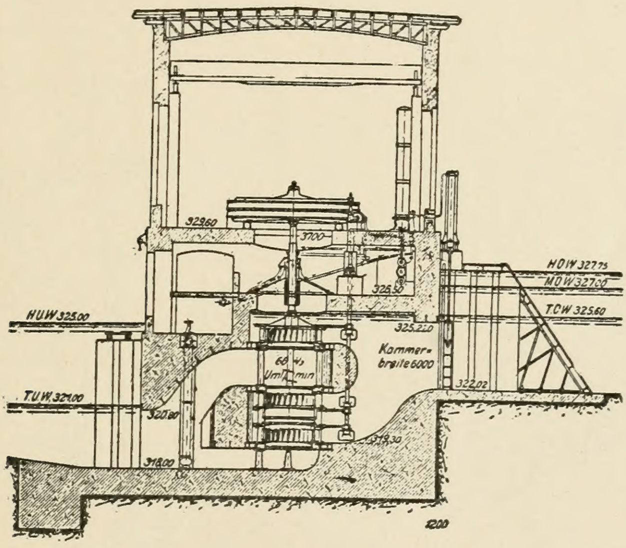
Beznau, River Aare.—One of the most interesting low head plants in Switzerland today is that situated on the Aare River, the Beznau Station. In it are constituted all the most recent improvements in the application of the water to the wheels, and in the wheels themselves are embodied the results of the experience of the past 10 years, with plants operating low heads with large variations. This plant was completed and put into operation in 1904, and was quickly loaded up with consumers in the surrounding country.

The available fall varies between 10 and 15 feet, and, owing to this variation, the vertical turbine units consist of three runners, 7 feet 6 inches diameter. One pair of runners is at the bottom, right and left, and the third above, discharging downwards into

the draft chamber of the upper runner of the pair. At a medium head of 13 feet, 1,000 horsepower is obtained on each unit at 67 revolutions per minute, using 890 sec. feet of water. The whole unit is supported by hydraulic pressure beneath a disc, so as to reduce the weight on the step bearing, and the small inequalities of this are further balanced by oil pressure from special pumps.

The power secured in these units varies between 7,000 and 11,000 horsepower for the whole installation of nine units.

The generators are of the umbrella revolving field type, 800 kilowatt each, three-phase, wound to 8,000 volts at 50 cycles, and were built by Brown, Boveri & Co., of Baden. Local distribution is at the generating voltage, while long distance is at 25,000 volts up to 20 miles. The latter voltage was the highest in transmission operation in Switzerland at the end of 1905. The total length of transmission lines of this plant in 1905 was 70 miles, the number



Section Through 1,500-Horsepower Francis Turbine Unit

of localities served was 61, the population 250,000, the number of transformers 60, and stations 31, while the average power of motors served was 100 kilowatt, in which respect this plant stands third in the country.

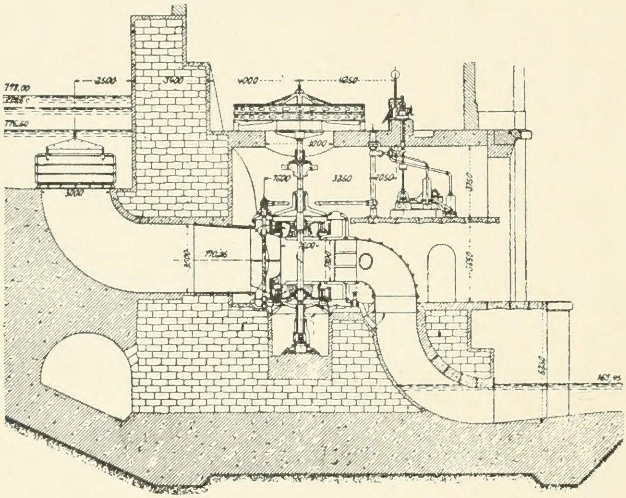
Prices of power are generally as follows: For lighting, 16 candlepower lamps, $4 each per year, continuous service. For motors on 10-hour basis, flat rate, 1 horsepower at $43, 10 horsepower at $39, 50 horsepower at $34, and 100 horsepower at $32. For 24-hour basis, 1 horsepower at $56, 10 horsepower at $49, 50 horsepower at $44, and 100 horsepower at $41.

Trezzo, Adda River, Italy.—The Trezzo plant is one of a series owned by the Edison Co., of Milan, and has only been recently put in operation. The Adda River at this point (25 miles

northeast of Milan) makes a horseshoe bend around a rocky hill, and the power project consisted of draining the river at the crown of the bend and placing the power house alongside of the rock cliff, discharging the water from the tail races through tunnels under the hill to the river below. The low head thus obtained, only 24 feet, required vertical shaft type of units with low speeds and a corresponding large volume of water with many units.

Against the high cliff of the river, in the horseshoe, the power house was constructed, having its face parallel to the river flow opposite, yet almost square against the current on the approach to the curve; this arrangement provides ample water with minimum deflection, and at the same time produces a sweeping current to carry past debris, etc. The station is situated about 300 yards upstream from the sluice gates of the dam, and is a large and very handsome structure, built entirely of stone.

There are ten main water entrances, each 22 feet wide, and



BEZNAU: SECTION THROUGH UNIT

two exciter inlets. These represent as many units and the water in each, after passing screens and gates, enters a wheel pit with its vertical turbine, thence into the tail pit and common bay, about 300 by 60 feet, in the rear of the station. From this point the water is conveyed by means of two tunnels beneath the cliff to the lower river. For a distance of 150 feet above the station and in continuation of the face of the water inlets, a series of ten overflow weirs is arranged to take care of slight inequalities in the river level.

The vertical turbines are Francis type, each of 1,500 horsepower capacity at 105 revolutions per minute; the first six and the two exciter units are by Riva Monneret & Co., and the seventh is by Escher, Wyss & Co., of Zurich. Considerable use has been made of reinforcing steel in the concrete foundations and settings

of these machines. The governors are connected by two stems to the gates. The generators are of three-phase revolving field type, two at 50 cycles, and the remainder at 42 cycles, and are built by Gadda & Co., Milan.

In the arrangement of switches, transformers, arresters, instrument boards, control, etc., this station is very complete and roomy, and the whole large wing at the end of the station is occupied by this apparatus. The distant control apparatus is, in itself, a very perfect arrangement, permitting complete operation from table switchboard to isolated apparatus in different compartments of switch and transformer rooms.

Four transmission circuits, three to Milan and one to Bergamo, are now in operation at 13,000 volts, carried on structural steel towers, known as the "Elastic" type. The function of these towers is that while rigid at right angles, they will oscillate slightly in the direction of the line, creeping of the cables being prevented by guying at intervals. These towers are 40 feet high above the ground, built with two legs (channel section) 7 feet apart, and each leg set in concrete 5 feet deep; the top of each leg member carries two circuits.

Lyons Installation on the River Rhone.

The city of Lyons with its population of half a million, is second in size, but first in industrial importance, among the provincial cities of France. This distinction is largely due to its geographic situation, since it is practically in the center of the country, and is located at the confluence of two navigable rivers, the Rhone and the Soane; hence, secures for it a large provincial trade, and makes it an ideal distributing center. The surrounding cities and towns contribute their share toward this activity; notably St. Etienne, with its steel works—the largest in France.

The Societe des Forces Motrices du Rhone first undertook in 1894 the construction of a hydro-electric plant for the purpose of transmitting power to Lyons, a few miles distant, and thus became one of the pioneer European hydro-electric power producers. The site chosen on the Rhone, above Lyons, is at a point where on account of the rapid and swift streams in a broad valley the main channel has been canalized by the government. The general scheme of power development comprises a head canal from the Rhone to a power station site, thence a tail race to an outlet in the Rhone, below the rapids, a total distance of about 11 miles, by which a head of about 35 feet is produced.

The generating station has frequently been noticed in the technical journals during the past few years. It is not the intention in this article, therefore, to enter into elaborate details, but simply to set forth the engineering features of this notable installation. The building itself is about 475 feet long, and is built largely of concrete, trimmed with stone and tiles. The units are directly connected; of the vertical shaft type, 16 in number, each of about 1,250 net horsepower, under normal conditions of the river; there are also three exciter units. Water is led to the turbines from separate bays on the upstream side of the station, each having its

own screens and sluice gate. The latter is unique, as being in the nature of a cylindrical drum, 10 feet in diameter, closing the top of a vertical inlet pipe. It is raised and lowered by a chain hoist worked from within the station.

The units are arranged in line at about 27 feet centers. The right central units, four on each side of the central bay, which contains the exciter units and switchboard, are operated by Jonval turbines, made by Escher, Wyss & Co., of Zurich, the installation of which was completed about 1897. These are of a special type, having a three-stage runner with downward discharge into a draft tube, and water fed to it through three separate and parallel distributors or guides at about 45 degrees; all fitted with cylinder gates. The thrust is provided for by a large disc or piston, about 6 feet diameter, attached to the shaft within, and at the top of the case. The closed chamber on the upper side of the piston is connected to the tail race. Regulation is secured by a special governor, consisting of a rotating disc and servo-motor actuating valves in conjunction with a high-pressure oil pump, by which the gates of the turbine are operated. This turbine gives an efficiency of about 76 per cent at full load, and the governor is said to regulate within a speed variation of 4 per cent on a change of half load.

While Lyons is in Southern Europe, freezing weather is frequently experienced. In the winter of 1904-05 the thermometer went at times as low as 5 degrees Fahr. above zero; on which occasions the station experienced trouble from frazil ice. This had the serious result of occasioning several days' shut down. It is a question whether this ice is formed in the upper river, in the foot-hills of the Alps, or immediately at the station; the company's engineer inclines to the latter opinion and has tried many artifices to obviate the trouble, but without success. At the time of the writer's visit, January 24th, 1906, the thermometer was down to about 15 degrees Fahr. and in anticipation of trouble, two 25-horsepower steam boilers on scows were supplying live steam at about 8 pounds pressure to the covered forebays at the screens and sluice gates. To a Canadian in Southern France, in the heart of the silk country, this presented an interesting spectacle.

The power now in use from this station amounts to about 14,000 horsepower at normal conditions. Of this about 2,000 horsepower is traction, 3,000 horsepower lighting, and the remainder mixed motor load. The prices charged for this power may prove interesting, and should be considered with the fact that a good quality of steam coal at Lyons costs about $4.25 per ton.

The prices for motor power are as follows: Up to 100 horsepower at 11½ cents per kilowatt hour; for over 100 horsepower at $34.00 per horsepower per year on a 12-hour basis, and $45.00 on a 24-hour basis. There is a sliding discount on the above prices as follows: On a bill of $20.00 per month, 1 per cent; on $50.00 per month, 2½ per cent; on $100.00 per month, 5 per cent; on $200 per month, 7½ per cent; and on $300 per month, 10 per cent. For lighting, which the power company itself oper-

ates directly, the charges are as follows: On meter system, 13 cents per kilowatt hour for stores, hotels, cafes, etc.; 16 cents per kilowatt hour for houses. If on a flat basis, the lighting rate is as follows: For a 16-candlepower lamp, burning 750 hours, per year, $4.20; for 10-candlepower, $3.75; for supplementary hours, add 6/10 cent for 16-candlepower and 4/10 cent for 10-candlepower for each hour. In the flat rate the bill is determined by a time meter.

Medium Head Plants

There is perhaps not a great deal to be noticed in the plants of medium heads, say between 40 and 100 feet or more, as they are generally of types similar to many American installations. Two plants, however, have been chosen for particular features, which are especially interesting to electrical engineers.

Vigevano Plant, near Milan, Italy.—Milan, which may be said to be the electrical city of Central Europe, is developing such a tremendous business in power that the actual supply has been quite behind the demand, and the result is that the electrical companies in the field have been using every means to increase their output by the exploitation of new hydro developments.

The new installation at Vigevano, on the Tessin river, 20 miles west of Milan, is a recent result of overburdened generating stations, and was placed in operation in 1906. It illustrates one of the latest types of hydro-electric stations to be adopted by Italian engineers.

Water for this plant is brought through canals three miles, to a forebay above the power station, having an overflow, screens and inlet sluices to the steel penstocks, which are 6 feet 6 inches diameter, one for each unit. The penstocks are about 200 feet long and enter through the station wall into the tops of the wheel cases. As a generating station, the arrangement of this plant is ideal, and upon entering, the visitor is impressed with the convenient and roomy arrangement. The turbine and generator units, five in number, are arranged abreast in a long hall, the two exciter units being at one end. At the same end is the switchboard, mounted on, and under, a floor, which is 6 feet above the main floor. The whole hall is about 340 feet by 40 feet. Alongside the gallery is an enlarged wing, containing all switching and transforming apparatus, the arrangement of which in convenient sequence, roomy spacing and isolation is very clever. In the introduction of these features the European practice in design within the past two years is quite marked.

The turbines are by Riva Monneret & Co., Milan, four units being installed at the time of the writer's visit, on February 6th, 1906, and one being still in the shops. The type is horizontal shaft double Francis inward discharge, into a draft chest; the cases are exposed and form the termination of the penstocks. Each turbine unit works under a head of 61 feet, developing 1,400 horsepower, using 270 cubic feet of water per second. The governors are of a special oil type, recently perfected by the turbine makers, sensitive and very powerful for their size; the writer

looked at the governors, especially to discover periodic hunting, while the station was running in parallel with a steam plant at Milan, but could see no injurious irregularities. The generators, by Gadda & Co., Milan, are directly connected, three-phase, wound to 2,750 volts at 42 cycles.

St. Maurice Station, Switzerland.—The St. Maurice-Lausanne installation, generating power from the Rhone, east of Lake Geneva, and transmitting by direct current to Lausanne, 35 miles distant, has become world-famous as being the pioneer D. C. transmission system in commercial operation under the Thury patents.

Not only are the electrical features novel, but the hydraulic arrangements are also most unique, especially in the head works and in the hydraulic governors.

The Rhone is subject to great fluctuations in this region, being essentially a torrential river, and in the late summer and winter periods the flow runs to such a minimum that it is necessary to use special means to divert the water into the head works. For this purpose a permanent dam not being permitted or advisable, a device was resorted to whereby a movable dam structure is let down into the river from an overhead bridge. The bridge is a steel Howe truss on stone piers; from the floor is suspended a series of hinged frames which can be lowered so that their lower ends rest in seats in the river bed. These frames are then filled in with wooden stop logs to the desired height to divert the water to the inlet of the head canal alongside.

From the intake, water is conveyed by open cut and closed conduits, nearly two miles, to a forebay above the power station, whence three penstocks of 8 feet diameter, and about 1,500 feet long, lead to the turbines.

There are at present five power units in this station, each nominally 1,000 horsepower. The turbines, working under 110 feet head, are of the Francis type horizontal shaft, with snail shell case, running at 300 revolutions per minute. Water is introduced from beneath the floor from the penstocks. Each turbine operates two direct current generators, and all five turbine units are governed in parallel from one governor, specially designed for this purpose.

The ten generators are of a special Thury type, giving 150 amperes at 2,300 volts. Connected in series the ultimate line voltage becomes 23,000 volts, and is transmitted over two wires to the step-down or distributing station in Lausanne, where by series motors the current is taken off to the secondary outlets. The electrical portion of this plant has been so often described in the technical press, especially during the past three years, it is not the intention here to do so further. There are features of D. C. transmission and operation, however, which might be mentioned as of interest.

It is claimed for the Thury system that while the generating apparatus is much more costly than for alternating current—as much as 75 per cent in excess—the switching gear and transformers, and buildings therefor, necessary for the alternating sys-

tem are absent in the direct current system; the total result being a cost very close to, or perhaps less than the alternating.

In the transmission line, however, a great saving of first cost and operation exists, owing to cheaper insulators, less copper, smaller spacing of circuits on poles, cheaper and simpler lightning protection. The actual experience with lightning in operating D. C. and A. C. transmission systems in France and Switzerland has, during the past two years, been much in favor of the D. C. The St. Maurice-Lausanne line, which has been in operation for five or six years, has seldom had a shut-down due to lightning, and as this line and the new Moutier line, also singularly free, are in the Alps, where lightning disturbance is at its worst, it is claimed that their immunity from trouble has been entirely due to the system.

High Head Plants

High head power installations are rapidly becoming the most numerous and important types in the Alps, for the generation of power. Certain localities in Switzerland have been specially developed in this respect, but there are also many such plants in the Alps, in France, Italy and Austria, as well as in other portions of the continent, especially where expensive fuel and a transmission market has offered remunerative investment.

Without enumerating the many plants, especially in the Central Alps, varying in head up to, in one instance, 3,140 feet, near Territet—the highest in the world—the writer has selected a typical new Swiss installation, a new French plant in Savoy, and an Italian one south of Naples. Each of these has special features of interest.

The Olevano Plant, near Naples, Italy.—The Olevano installation is on the Tusciano river, about 50 miles south of Naples, has a capacity of 6,000 horsepower and current is transmitted to various towns en route to Naples, passing Vesuvius at its base. Its transmission lines suffered severely in the recent eruption. The uses are mainly for lighting and mixed power in small units, such as for fabric and textile weaving, machine and woodworking shops, but more than all for the macaroni factory, which is the flour mill of Italy.

The head water is brought about three miles by canal and tunnel to a forebay on the mountain side, thence down to the station in a steel penstock, 40 inches diameter. There is now being used only about 70 sec. feet of water, under a static head of 960 feet. The penstock is about 2,000 feet long and is carried down the mountain on 65 concrete saddles. The lower end is horizontal and distributes to five power and two exciter units. The upper portion of the penstock is of ¼-inch steel and the lower ¾-inch.

In the generating station the five units at present installed are each of 1,200 horsepower output capacity. The waterwheels are of a special horizontal shaft, impulse type, manufactured by Piccard, Pictet & Co., Geneva, Switzerland. They are rated nominally at 1,400 horsepower, run at 500 revolutions per minute, and each

uses about 14 cubic feet per second of water. The runner, 4 feet 8 inches diameter, consists of two heavy cast iron rims, having the steel vanes set between; this is mounted in a spider attached to the shaft. The water is introduced through a pair of nozzles at 90 degrees with each other, which are formed in one casting bolted to the end of the supply pipe; the nozzles lie up to the inner periphery of the runner and the latter discharges outwards similarly to the Girard turbine. The discharged water is caught in a tail pit below and the whole (pit and runner) is covered with a casing. The nozzles are opened and closed by a bronze tongue or throttle deflecting within the opening on a shaft which is linked up to the governor.

In the earliest nozzles on this type of wheel, the manufacturers had formed the whole nozzle head and tongue of bronze, an expensive feature in large units, especially when renewals are frequently required. Later types, however, such as the present, are built merely with bronze lips and tongue, as it is found that these —especially the lips—are cheaply and quickly renewed. The writer saw and obtained a photograph of the eroded nozzle from one of the wheels in this installation, which had been in use 12 months; it presented a good object lesson of the power of sanded water under high head, which forms one of the difficulties in the operation of this plant. It is to be noted that there is comparatively no erosion of the vanes of the runner under these conditions.

It is stated that in tests on these hydraulic units by the company, the following efficiencies were obtained: At full gate, 76 per cent; at three-quarter gate, 73 per cent; at half gate, 68 per cent; at quarter gate, 62 per cent. The generators and electrical apparatus made by Westinghouse present no especially new features beyond the general modern practice of switching and isolation as designed by that house. The generators are three-phase, wound to 3,000 volts, and static oil-cooled transformers step up to 30,000 volts to the line. The line consists of two trunk circuits which are carried on one line of structural steel poles, about 180 feet apart. The wires are 7 mm. copper, and are 24 inches apart.

Prices for power in the cities named vary according to amount and distance from generating station. At Salerno, 16 miles distant, 200 horsepower is sold for $25 per horsepower year, on a 24-hour basis; larger blocks of power are sold nearer Naples at $30 per horsepower at 24 hours. There are two consumers near Naples using 800 and 1,000 horsepower each. Coal at Naples is about $8 per ton.

Gavet Station, French Savoy.—This installation is situated on the Romanche river, and is in the heart of the French Alps. The distinctive features of this river are remarkable, for its flow is very small, being in dry weather only about 300 sec. feet; while the flood discharge is 30 times as much. Its descent is very rapid, hence high heads prevail, and in the seven plants installed on 12 miles of its course 40,000 horsepower is developed. This river offers a notable example of the utmost development of mountain streams for power generation.

The power is used for numerous electro-chemical industries, including calcium carbide works, and especially the "electric steel" works of Keller, Leleux & Co., at Livet. At Livet is also located the municipal plant for Grenoble. A transmission line from the latter, 24 miles long, to Grenoble, has a considerable portion carried on wooden poles incased in from 1 to 2 inches of concrete. Unique as this is, it appeared to have given fair satisfaction in the three years' operation before the writer saw it.

The Gavet station, completed in 1906, is 16 miles from Grenoble and has an output of 5,000 horsepower at the lowest stage of the river. The head works are very ingenious, having besides the dam, several weirs and settling basins for the purpose of freeing the water of gravel, sand and silt, which is carried in great quantities in mountain streams. The flume or tunnel to the power station is 7,000 feet long and about 10 feet square.

The tunnel terminates in a small covered forebay high up the face of the cliff above the station, having outlets for two penstocks and one spillway. The penstocks follow down the cliff, and are 7 feet diameter, about 500 feet long, and each branches to the three main and two exciter units at the rear wall of the station.

The station is of rubble stone, having a generating room, commodious switchboard gallery, wire ducts, transformer and arrester rooms.

The turbines develop 2,000 horsepower each, working under a head of 190 feet; they are of the horizontal shaft, single spiral Francis type, built by Piccard, Pictet & Co., of Geneva. The distributor gates are swivel style, with an actuating gates ring carried on arms fitted with springs, to positively take up lost motion. The governors are by the same makers, arranged with a new device on the fly balls, to stop petty vibrations. The main shafts have flywheels and Zodel flexible leather link couplings.

The generators are by Schneider & Co., Champagne, revolving field type, three-phase, 4,000 volts, 231 amperes per phase. The transformers step up to 26,000-line voltage, the same as the Avignonet station, with which this station will at times be run in parallel, 24 miles distant. The line is at present carried on wooden poles.

Good quality steam coal in Grenoble costs about $5 per ton. The prices of the Societe Grenobloise are, in general, as follows: For 24 hours' service the average prices (variable on account of distance) are, say for 100 horsepower, $30 per horsepower year, and for 500 horsepower about $26 per horsepower year. In 500-horsepower quantities, prices run down as low as $18 for transmitted power, and even to $12 at the station. This company has now 15-year contracts for about 15,000 horsepower, with some customers 100 miles distant.

Vallorbe Development, Switzerland.—Vallorbe is a small city in Canton Vaud, on the Orbe river, north of Geneva, and two miles from the French frontier. The river empties from Lake de Joux, which is 800 feet above the valley, through an underground passage, and commences its course as an open river from a gigantic bubbling spring.

The Vallorbe plant has been in operation since 1904 with five units; space and connections are arranged, however, for three more, while ultimate extensions will provide for a total of about 12 units, if sufficient water can be secured. The present output of this plant is 5,000 horsepower.

Hydraulically this development is most remarkable, owing to the nature of the water supply. Lakes de Joux and Brenet have six and seven surface outlets, respectively, but the main discharge is the subterranean river, which forms the Orbe. In order to get sufficient water, then, all the small surface outlets were dammed, and the lakes were formed into a huge reservoir, in which the concessions permitted the fluctuation of the level within limits of 12 feet, artificially controlled. At certain periods of the year these lakes have regularly risen a number of feet, according to a law determined by observations extending over many years. This increase is now partially secured by the new works, and is held up for power purposes. The subterranean flow, however, still proceeds. Hence the development presents the unique feature of being dependent entirely on storage water or such as can be stolen from the natural outlet.

The water taken at the intake in the lake, after passing racks and gates, is carried by means of a rectangular concrete-lined tunnel to a point on the lower hillside, where a forebay and head house are located. The tunnel conduit is 6 feet 6 inches wide, 7 feet high and about 8,700 feet long.

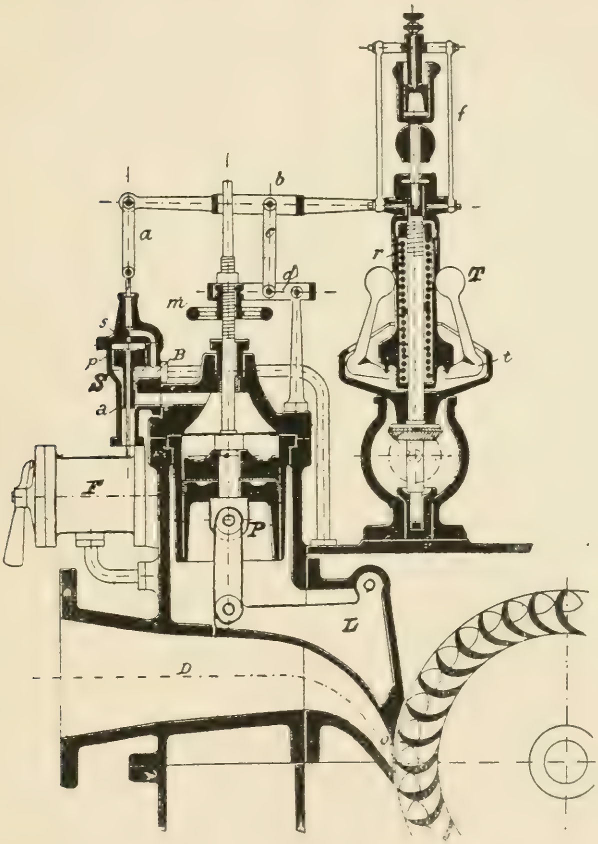
The forebay works can be seen high up the mountain side. Water issuing from the tunnel first passes a coarse rack, enters a chamber having an overflow weir with adjustable crest, thence passing head gates enters the penstocks. Overflow water spills into a large chamber, from which steel pipes carry it down the slope. The penstock varies in diameter from 48 inches at the top to 40 inches at the station, the respective thicknesses of plates being 5/16 inch and 13/16 inch, while the distributor portion within the building is 1 inch. The total length of penstock is about 2,000 feet; it is carried on concrete piers with heavy anchorages, and there are four expansion joints.

The two spill pipes are about 2,400 feet long, about 3 feet diameter, 7/16-inch plate, and with rivets countersunk on inside. These have several expansion joints and automatic air entry valves. They discharge water into the river below the power house.

In a plain concrete building are now installed five 1,000 horsepower units and two exciters, operating under a head of 770 feet. These units are contained in a room, 160 feet long and 40 feet wide, while in a central wing are located the busses, switches, switchboards and arresters.

The waterwheels are by Escher, Wyss & Co., having single nozzles with one runner. A feature of this wheel is its automatic hydraulic regulator. In plants of this pressure, European builders are using filtered water from the penstock instead of oil as a medium. This involves a mechanical filter on the governor to insure clean water. Escher, Wyss & Co. have what they call a "revolving filter", *F*, which can be worked by hand. The cycle

of operation from the fly balls to the relay valve, with its fine adjustment to prevent "racing", through the level system to the regulating valve, *S*, thence to the main cylinder and piston, *P*, and to the throttling lip, *L*, can be readily followed. The generators are built by the Oerlikon shops and are three-phase, 50 cycles, 13,500 volts at 375 revolutions per minute; they are connected to the wheels with Zodel couplings. The switching is specially interesting, owing to the wide system of distribution, but is simpli-



VALLORBE: SECTION THROUGH HYDRAULIC GOVERNOR

fied by having no transformers. Instrument pedestals of American type are installed, and the chief operator from his gallery can easily control all operations of the station. A unique arrangement of hydraulic jet lightning arrester is installed on a floor above the gallery. This combines a horn type arrester with a water resistance together with a choke coil and metallic ground wire.

For the distribution of this power and that from the lower station there is planned a network of over 250 miles of line, the

farthest point served being about 50 miles distant. A characteristic is the widely scattered network of power service. The total population in the localities is about 100,000, the number of localities or communes designed to be served is 212, with 235 transformer stations. This is a striking example of the extensive detail of distribution which European companies are now carrying out, and both the people and the power companies of Ontario can at the present time benefit materially by following Swiss lead in this respect.

The power in these places is used for lighting, street railways, cement and brickyards, all manner of agricultural needs, such as churning, etc., watch-making, weaving and miscellaneous shops and industries.

Small transforming stations, of standard design, about 10 feet by 12 feet inside and 27 feet high, with three floors, are erected in many localities. These are built of brick or concrete and are cheap and neat in appearance. Some in city streets and parks are most artistic.

Prices are as follows: For light, 16-candlepower lamps, from 400 to 800 hours per year, $3.60; over 800 hours, $4.40. For heating, 8 cents per kilowatt hour. For motors, flat rate, on 11-hour basis, less than one horsepower, $60 per year; one to two horsepower, $40; nine to 11 horsepower, $37; 25 horsepower, $33; 50 horsepower, $30; 100 horsepower, $29. On 24-hour basis add 25 per cent to above figures. For motors on meter rates, from 2.5 cents per kilowatt hour at one horsepower, down to 1.4 cents at 100 horsepower.

The Manufacture of Iron and Steel

By S. M. Rogers

To describe in detail the modern methods of manufacturing steel would involve the use of numerous photographs and a very large space. It will, therefore, be the purpose of this article to first mention some of the important historic facts relative to the iron and steel industry, and briefly describe the most important processes of making steel, namely—acid Bessemer and acid and basic open-hearth.

Iron is found in different combinations all over the surface of the earth, but very seldom, if ever, in its pure state. Nature in various ways has collected the ores in masses sufficiently rich in metallic content for commercial purposes, but all ores contain more or less foreign matter, which must be taken care of by the addition of suitable fluxes in the process of smelting.

The most important commercial iron ores are: Magnetites, hematites and spathic or carbonates.

Magnetites are generally the richest ores, and when pure, contain 72.4 per cent metallic iron, and are found in large quantities in the Lake Superior district and in Sweden. They are usually Bessemer in quality, which means that the phosphorus must be 0.040 per cent and under in order to produce a pig iron under 0.100 in phosphorus.

Haematite ores generally consist of anhydrous ferric oxide in various shades of colors, depending somewhat upon the treatment and presence of foreign substances. In some localities they are Bessemer quality.

Spathic or carbonate ores, in their purest form, contain about 48 per cent metallic iron, although quite variable in appearance and character, owing to the impurities, which are usually of a calcareous nature. These ores are of comparatively little importance in America, while in Great Britain they have considerable value.

History does not tell us when, where or how iron was discovered. There are many ancient references to the use of iron which show that it was made more than 4000 years ago. In the British Museum there are specimens of iron obtained by the Egyptian and Assyrian explorers, and one article of iron which was found in the Great Pyramid of Gizeh and which is believed to be the oldest piece of iron known, and to date from 3733 B. C. This specimen is a flat, irregular, wedge-shaped piece, about 3 inches wide and 9 inches long and of uncertain use. It is believed to be even older than the earliest bronze. While it appears that the earliest information concerning iron comes from the Egyptians, the Assyrians seem to have been first to use that metal for the manufacture of tools and weapons. In the British Museum can

be seen a beautiful collection of instruments, obtained from the ruins of Nimroud, which clearly indicate considerable skill in the manufacture of iron implements, also specimens of an ornamental character, which were manufactured by casting bronze around a core of iron, thus showing that the ancients knew that iron was less fusible and less resistant to corrosion than bronze.

It is well known that many centuries before the Christian era, India was well versed in the art of making iron, as is indicated by the famous iron pillar at Delhi, standing 22 feet above the ground, having an estimated weight of more than 12,000 pounds. It is said to be remarkably pure and very malleable. About this time the Greeks showed some knowledge of the iron industry, although their war implements were made of bronze, thus indicating that iron was rare, as is also evidenced by the fact that iron articles were given as a prize to the winner of their annual games.

From the historic pages of Pliny we learn that the use of iron became general all over civilized Europe after the formation of the Roman Empire. The Romans also had considerable knowledge of how to mine and smelt ores and to harden and temper steel implements. They had some knowledge of the famous ore mountain at Erzgebirge, which after being operated for more than 2,000 years, is so enormous in size that the effect in reducing the supply is scarcely noticeable. It is probably the most ancient ore mine in the civilized world, in which the industry still flourishes.

Cast Iron

The introduction of cast iron marked a new and important era in the manufacture of iron and steel. Before the development of the German "Stückofen", wrought iron had been produced from the ore in a single operation in a semi-solid or pasty form, which necessarily limited its commercial use to comparatively small articles of manufacture.

Through the great energy of the German metallurgists, blast furnaces of a gradually increasing size were introduced until it was possible to keep the iron and fuel in contact until the metal became sufficiently carburized to remain in a fluid condition at the temperature of the hearth, thus making it possible to cast this new metal into any desired shape and size.

Thus modern iron-making may be said to date from the development of the blast furnace, which was first used in Belgium, about 1340. The fuel used in the blast furnace for smelting iron ore was charcoal. As the industry grew, the supply of wood for making charcoal became a very important factor, and in localities like England the enormous drain on the forests caused the enactment of legislative restrictions, which resulted in a serious decline in iron-making. More than a century later, the development of the coke-making coals came in time to save this rapidly declining industry from extinction.

Iron was first smelted in America in Massachusetts, in 1644, and in 1784, there were 76 iron works in that state. In 1658,

iron works were established in New Haven, Connecticut, and a few years later in Rhode Island. The other New England states made no iron until the 18th century. Pennsylvania, at present the leading iron center in the world, was three-quarters of a century behind Massachusetts in getting started.

When George Washington became president of the United States, iron was being manufactured in nearly every state in the Union, which shows that iron and steel centers were more numerous then than at the present time. England remained our Mother

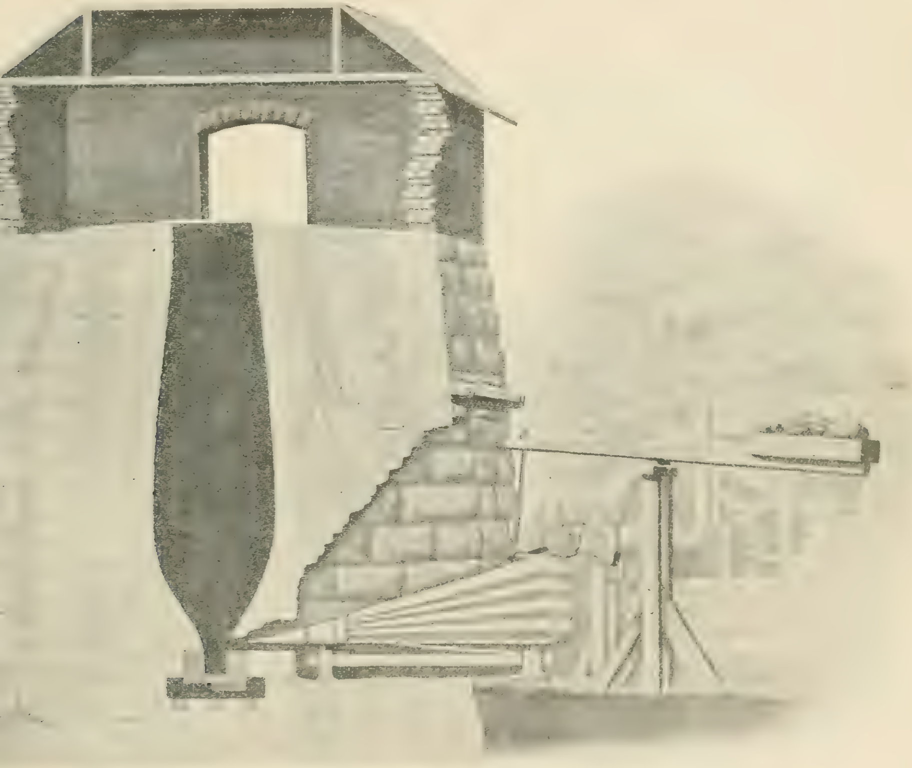


FIG. 1—SWEDISH BLAST FURNACE, SEVENTEENTH CENTURY

Country longer in an industrial sense than in a political sense, although it required a little more than a century after the Declaration of Independence to develop an iron industry comparable to that of Great Britain.

About the middle of the seventeenth century, British capital backed the first iron smelting enterprise in Massachusetts, which seems to be the earliest indication of the shortage of fuel supply in Great Britain.

To England belongs the credit of inventing revolutionary methods affecting the iron and steel industry. In 1740, the man-

ufacture of coke for blast furnace use was successfully accomplished by Abraham Darby, after many years of diligent labor. The importance of this invention was not fully appreciated by Great Britain nor any of the other iron producing countries until about the beginning of the nineteenth century.

The Puddling Process

The invention of the puddling process in 1784, by Henry Cort, gave a great impetus to the iron industry of Great Britain. The

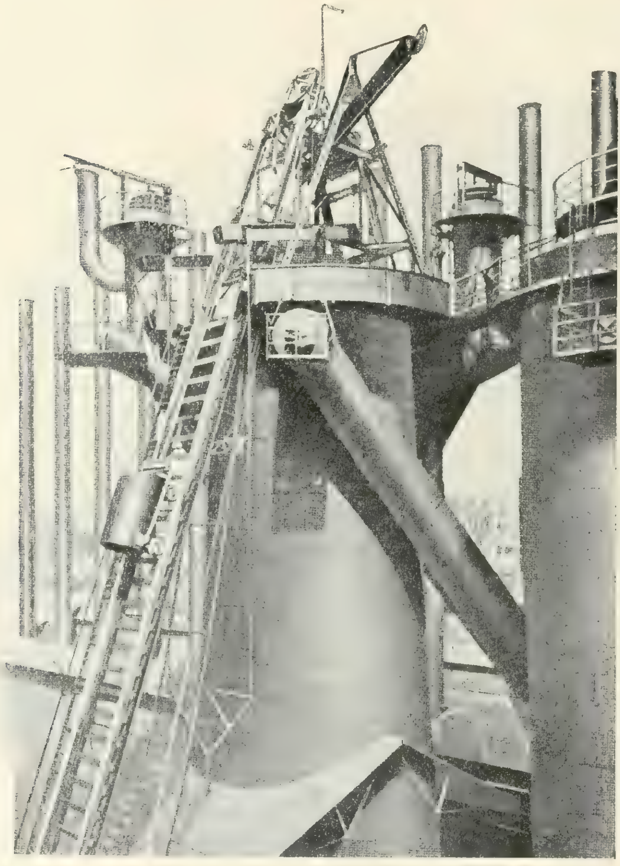


Fig. 2—Blast Furnace, Showing Automatic Charging Device

process consists of charging pig iron into a basin-like furnace with a fire behind a low cross wall, over which the flames and hot gases pass to the pig iron in the hearth. After the charge is melted and begins to boil, and the carbon and other metalloids are eliminated, the fusibility of the iron decreases, and the operator is able to transfer the mass in the form of a spongy ball from the furnace to a hammer or mechanical squeezer to remove the

slag and shape the mass for further heat treatment and rolling or hammering. Prior to Cort's invention, cast iron had been decarburized with the use of charcoal in small quantities of about 100 pounds, involving great expense, fuel and labor. With the development of the puddling process near the close of the eighteenth century, the United Kingdom was fast assuming a leading position among the iron-making countries of the world.

The Modern Blast Furnace

The general design of the modern blast furnace is too well understood to require a detailed description, the object being to

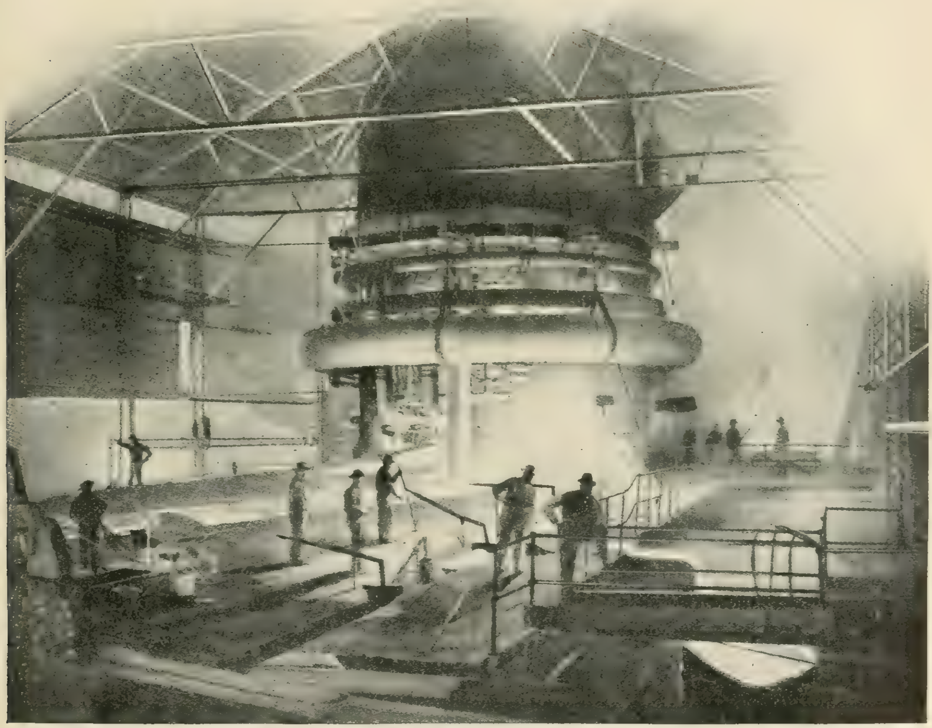


Fig. 3—Tapping a Blast Furnace

briefly explain the principal operations involved in the manufacture of pig iron.

Four kinds of materials are put into the blast furnace—fuel, iron ore and fluxes, charged at the top of the furnace, and air blown in at the tuyeres.

Four kinds of materials are discharged from the furnace—pig iron and slag, tapped from the hearth, and gases and ore dust, drawn from the top of the furnace.

The solid materials are charged in alternate layers in regular

order and in regular amounts. The fuel used is generally coke. The quantity required is approximately one ton of coke to every ton of pig iron produced.

As the iron is formed, it drops through the slag to the lowest point in the hearth, from which it is tapped about every four hours, and is either cast into pigs, or transferred to the metal storage or charged direct into the converter and open-hearth. The grade of pig iron produced depends upon the character of the charge and manner of operating the furnace. The percentage of silicon and sulphur contained in the iron is mainly under the control of the furnace man, while the percentage of carbon is automatic and quite constant. Practically all of the phosphorus in the charge goes into the metal.

Other materials, such as ferro-manganese, spiegeleisen, ferro-silicon and silico-spiegel, are products of the blast furnace.

The volume of air that is blown into a modern blast furnace of 450 to 500-ton capacity is 40,000 to 50,000 cubic feet per minute, at a pressure of about 15 pounds per square inch. The blast is forced through hot stoves and enters the furnace through the tuyeres at a temperature of 800 to 1,000 degrees Fahr.

The total weight of materials required for smelting pig iron is from seven to nine times the weight of the iron produced. More than half of this weight is atmospheric air, which is required for the combustion of the fuel, and approximately only one-fifth of this is oxygen.

The volume of gas drawn from the top of the furnace per ton of pig iron produced is about 160,000 cubic feet at a temperature of 400 to 450 degrees Fahr., having a thermal value of 85 to 95 b. t. u. per cubic foot. About 30 per cent of this gas is used for heating the blast; from 12 to 15 per cent is used to operate gas-driven blowing engines; 5 per cent is lost in washing, and the rest may be used to generate electrical power. The slag is mainly silica, alumina and lime, and is often used for making cement.

Acid Bessemer Process

The mechanical details of this famous process, invented by Sir Henry Bessemer in 1855, need no explanation. The basic principle of this process was the use of air as an oxidizing agent, which, when passed through molten pig iron, made it possible to develop the highest known temperature in the art of making steel. About one year after this process had been patented, the inventor made his first public announcement to the British Association in an address called "The Manufacture of Malleable Iron and Steel Without Fuel". It created intense excitement among the iron manufacturers, many of them undertaking further experiments, some of which were successful and some failures. Bessemer, recognizing that his process was by no means a complete success, continued his experiments until his invention became so complete that practically no improvement has been made except in some minor details of manipulation. From the beginning of this great invention, Robert Mushet recognized the importance of

adding manganese to the blown metal and took out patents covering the addition of manganese in all possible ways. Bessemer never recognized the validity of his patents, although some sort of an agreement was entered into, which prevented future litigation.

The Bessemer process is essentially as follows:

Molten pig iron is introduced into a converter (or vessel, as it is sometimes called), which is lined with siliceous material,

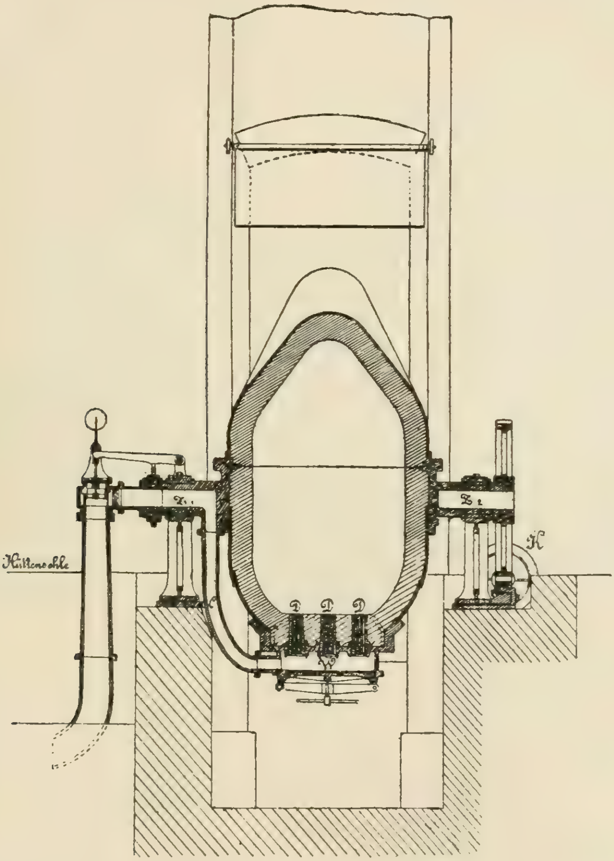


Fig. 4—Converter Section

from which the term "acid" is derived. A current of air is forced through the metal, which causes the silicon in the iron and the oxygen of the air to unite, and results in an increase in temperature and the formation of silica (SiO_2). At the same time a small portion of the carbon and most of the manganese are oxidized to CO_2 and MnO. Following this increase in temperature, the carbon is burnt to carbon monoxide, producing the brilliant flame at the mouth of the converter. When the carbon is all con-

sumed, the flame drops, which indicates to the blower that the converter must be turned down and the blast turned off, or the iron will be rapidly oxidized. Fig. 5 represents two Bessemer converters in action. The one on the right, showing the shorter flame, represents the beginning of the blow, or the burning of the silicon and most of the manganese. The one on the left shows the later stages of the blow, when the carbon is burning with a large and luminous flame. The subsequent shortening of this flame indicates the practical elimination of the carbon, or the end of the blow. As the blown metal is poured from the converter into the ladle, the required amount of spiegeleisen or ferromanganese is added, which is quickly dissolved and uniformly distributed through the mass. The ladle is then transferred to the casting platform, and the steel is teemed into cast iron molds, after which the molds are stripped from the ingots, and the latter

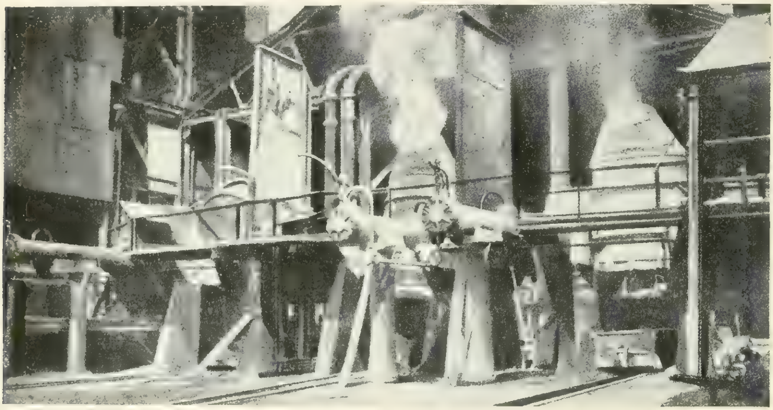


FIG. 5—BESSEMER CONVERTERS

are quickly transferred to what are called soaking pits, to be "soaked" or heated for the subsequent operation of rolling.

The pig iron used in the acid Bessemer process must correspond very nearly to the following analysis:

Silicon	1.25 per cent
Sulphur	0.06 per cent
Phosphorus	0.09 per cent
Manganese	0.50 per cent

The melting point of pig iron is considerably lower than that of steel. The increase in temperature in the converter, as explained above, is due to the oxidation of the silicon to silica. This increase in temperature is required to burn the carbon and maintain a sufficiently high temperature in the blown metal for casting.

If the silicon is too low, the temperature will not rise high enough for the final reactions between the metal and the manganese, and the steel will not be satisfactory.

It is also true that when the silicon is too high, the increase in temperature does not give satisfactory results.

The sulphur and phosphorus remain unchanged and may be found in slightly higher percentages in the steel, owing to a loss in other metalloids.

The value of Bessemer steel, when compared with open-hearth, depends almost entirely upon the purpose for which it is used. For the manufacture of certain grades of wire, Bessemer steel is far superior to open-hearth in every respect. It is also true that for certain purposes open-hearth is very much better than Bessemer. There are many reasons why the wire manufacturer will regret the day when Bessemer ores become so scarce (if they ever do) that the process must be abandoned.

The Acid Open-Hearth Process

The method is all that the name implies. It is carried on in a silica-lined hearth, in which a mixture of pig iron and wrought iron or steel scrap is openly exposed to the melting action of the flame. The method was invented and patented by the Messrs. Siemens, in 1856, or about one year after Bessemer recorded his invention. At first, great difficulty was experienced in obtaining a sufficiently high temperature, and about eight years later the problem was solved by a Frenchman named Martin, who applied the so-called regenerative system, which means preheating the gas and air before they enter the furnace, thus greatly increasing the intensity of the flame. This process, unlike the Bessemer, having a fuel supply entirely independent of the charge, may be continued indefinitely. The fuel may be natural gas, producer gas or crude oil. In acid open-hearth steel the sulphur and phosphorus are dependent on the composition of the charge, the same as in the acid Bessemer process, while the percentage of carbon, manganese and silicon in the resulting steel are under the control of the melter.

It is customary to regulate the proportions of pig iron and scrap in the charge so that the bath after melting shall be practically free from silicon and manganese. The excess of carbon in the bath is reduced by adding iron ore. The oxygen of the ore combines with the carbon in the bath to form carbon monoxide, which gradually disappears.

The progress of the work is observed by frequently taking test samples from the bath, and hammering and quenching them in water. The fractured surfaces of these samples indicate to the experienced melter the approximate amount of carbon the bath contains. When the metal is ready to tap, ferro-manganese is either added in large lumps to the bath, or in very small pieces to the stream of metal as it runs into the ladle. There is no satisfactory way to recarburize open-hearth steel in the ladle. The addition of crushed coke or hard coal to the steel as it runs from the furnace into the ladle is almost sure to produce very unsatisfactory results. The only proper way to recarburize steel in the ladle is to add melted spiegel, and this practice is not applicable to the open-hearth process. The quality of the steel aside from

its chemical composition depends largely upon the temperature during the process of melting, the condition of slag and bath during the refining period, the temperature at the time of tapping, the manner of making ladle additions, and the rate of teeming. Very much also depends upon the physical and heat treatment the steel receives after it is made.

Basic Open-Hearth Process

In construction, the basic furnace is the same as the acid furnace, except that the hearth is lined with basic materials, such as magnesite, burnt dolomite and lime. The walls and roof are constructed of silica bricks in the usual manner.

The process begins with adding to the hearth a charge of either cold or melted pig iron with varying amounts of wrought iron or steel scrap. In addition to the metallic contents of the charge, a calculated weight of limestone is added to take care of the slag-forming ingredients in the charge, such as silica (SiO_2), and oxides of iron and manganese, thus forming a slag strongly basic in character, which takes up practically all of the phosphorus and part of the sulphur contained in the charge. It is customary to regulate the proportions of pig iron and scrap in the charge so that the bath after melting shall be practically free from silicon, manganese and phosphorus, and contain approximately the percentage of carbon required in the finished product.

To meet the specifications in silicon and manganese, it is customary to add crushed ferro-silicon and ferro-manganese to the ladle as the steel is tapped from the furnace. When the required amount of manganese in the finished steel is high, it is better to add a part of the ferro-manganese in large lumps to the furnace a few minutes before tapping. In the basic open-hearth practice, it is desirable to use pig iron with silicon not over 1 per cent. This is especially important when the proportion of pig iron in the charge is 60 per cent or more. When melted pig iron is available, it may be taken direct from the blast furnace, although it is more satisfactory if the charge is drawn from the metal storage (or mixer). The growing scarcity of wrought iron and steel scrap for open-hearth requirements makes it necessary to use greater proportions of pig metal, which is quite objectionable in many ways. The percentage of steel produced from a given charge is correspondingly lower, because the metallic value in pig iron is about 93 or 94 per cent, as compared to 99 per cent or more in steel and wrought iron scrap.

Local conditions often require some variations in practice such as the "pig and ore process", which consists in first fusing upon the furnace hearth a mixture of ore and limestone, to which is added the melted pig iron. The oxygen of the ore and the silicon in the pig metal unite to form silica (SiO_2), after which a vigorous reaction takes place, causing more or less foaming for a considerable period of time. During the refining operations all of the iron added in the form of ore is reduced to the metallic state, correspondingly increasing the yield in ingots.

The basic furnace is sometimes used in connection with the

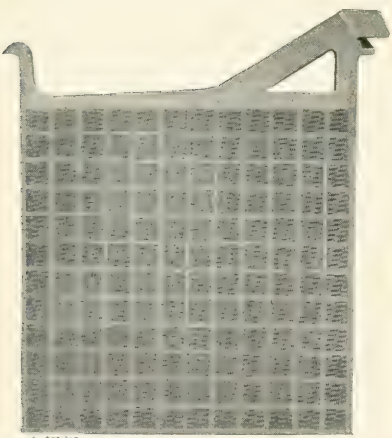
acid Bessemer. The molten pig metal is first poured into the converter and blown until the silicon and a part of the carbon and manganese are removed; the contents are then transferred to the basic open-hearth to remove the phosphorus and complete the removal of carbon from the bath to the desired point. This process is of particular value in localities where steel and wrought iron scrap is scarce. The quality of the steel made by the above process is perfectly satisfactory for all ordinary purposes. Basic open-hearth steel is softer than acid open-hearth of corresponding analyses, and is very much better for cold working; while for hardening and tempering purposes, acid steel is usually preferred.

The Various Applications of Storage Batteries

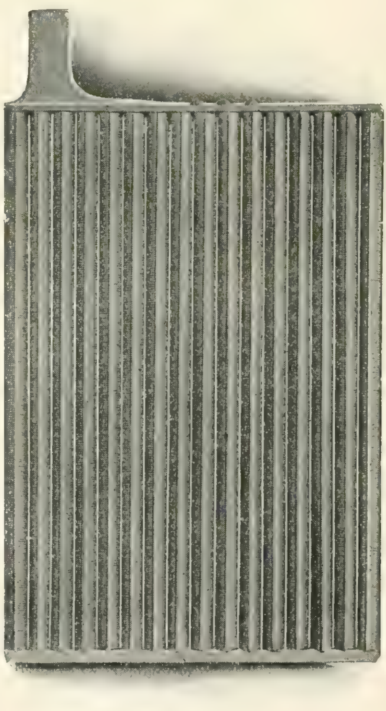
By A. B. Burk, Jr.

A short explanation of the storage battery may be necessary in order to avoid confusion of terms. This paper will deal only with what is known as the lead-sulphuric acid-lead type of battery, which is the only one that has survived in all classes of commercial work, of the various combinations tried to date.

The chemical theory of the storage battery has never been definitely settled, although many theories have been advanced to account for the reactions in a cell. An approximate idea of what goes on during charge and discharge may, however, be easily stated. From an elementary standpoint, a storage battery consists of two or more plates, positive and negative, insulated from each other and submerged in a jar of dilute sulphuric acid. The plates have as active material, either as part of the plates or held in



R Negative Plate



Iron-Clad-Exide Positive Plate

the grids, finely divided lead, which offers an enormous surface to the electrolyte, allowing electro-chemical action to take place easily and quickly. The plate called positive, when formed, becomes oxidized, while the other remains pure lead, usually spoken of as spongy lead. This combination has a potential difference of about two volts, and current will flow if the plates are connected through an external circuit. During discharge the positive plate loses its oxygen and both plates become sulphated, until, if the discharge is carried far enough, both plates become inert; the active material on each having reached the condition of lead sulphate. On again charging, the sulphate is driven out of both plates, and the positive plate oxidized, and this cycle can be repeated until the plates are worn out. Charging and discharging simply results in a chemical change in the active material and electrolyte, and the potential difference between the plates, and capacity is due to this change.

While the storage battery may be considered as dating back to 1860, it was hardly a commercial proposition until 1881, when the pasted type of plate was developed by Brush and Faure. On a large scale, it can be considered as dating back in this country some fifteen years. Improvements are being made in design, manufacture and installation so rapidly that few fields of electrical work can show a similar rate of progress.

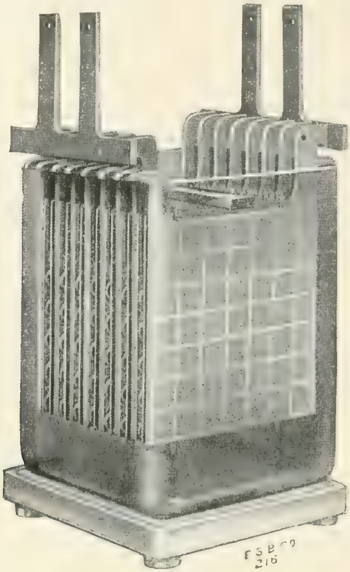
The heart of a storage battery is in the plates, of which there are two general types, those in which the active material is integral with the support, and those in which the active material is not. The first is usually called the Plante, the second the Faure type. But it is rather difficult to classify all plates, as many have some of the characteristics of both general types.

Any plate is a compromise between capacity, life, weight and cost, and since there are many different service conditions, to secure best results various types of plates are in general use. The pasted or Faure type is used in vehicle and in most portable work, or where space is very valuable, as it combines high capacity with reasonable weight. Where life and capacity are the most valuable considerations, a Plante type plate is chosen. For low or high discharge rates, either a pure lead or a grid type may be chosen, dependent upon plate characteristics and conditions of service.

A storage battery has certain voltage characteristics, which are inherent and must always be considered. On charging a normal cell, the current being constant, and the cell in a discharged condition, the voltage starting at about two volts, will rise rather rapidly, then slowly until the cell is nearly charged, when it will again rise rapidly until a maximum is reached. This maximum may vary from 2.4 volts to as high as three volts, depending on the type of plate, concentration of electrolyte, temperature, age of plates and current density. On opening the circuit, the cell voltage will drop rapidly to about 2.2, then slowly to from 2.16 to 2.10 volts. On discharge, the voltage will drop from 2.10 to a lower figure, depending upon the rate of discharge, then slowly drop until the end of discharge, when it drops off quite rapidly to a point from 1.9 to 1.4 a cell, at which point the

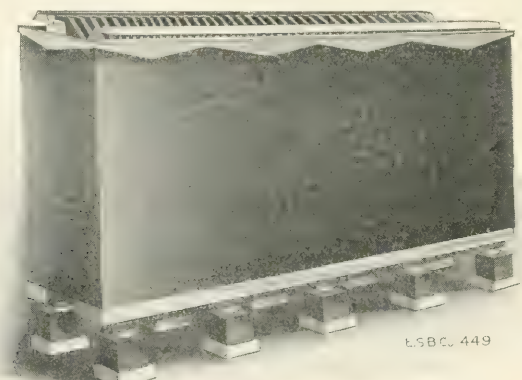
cell is considered discharged. This "cut off" voltage varies with the type of plate, and with the rate of discharge.

It is, therefore, necessary in charging a storage battery to



CELL FOR STATIONARY BATTERY IN GLASS JAR

impress upon its terminals a higher voltage than the nominal cell voltage, and on discharge, to use a lower voltage. In order to charge from a circuit of fixed voltage and discharge on a similar



CELL FOR EMERGENCY BATTERY, TYPE 131-H-EXIDE

circuit, it is necessary to have some means of supplying this voltage. There are various methods of doing this.

In the first place, we may vary the supply voltage from a special or regular generator. Taking a proper number of cells,

we can add what are called end cells, or cells in addition to the original or main battery, so arranged that they may be cut in or out of circuit. Thus at the start of charge, sufficient cells would be in the circuit to allow a proper rate of current to flow into the battery. As the voltage of the cells rises, the end cells would be cut out, until only the main battery is on the line. On discharge, these end cells would be added to the main battery, keeping the total voltage constant, notwithstanding the drop in individual cell voltage.

By using two end cell switches, in which the points are cross-connected, it is quite possible to impress a high charging voltage on the battery and end cells through one switch, while the other switch can be connected to the load circuit, allowing a portion of the charging current to go through both switches without raising the voltage on the load circuit.

In place of end cells in small batteries, what are known as counter E. M. F. cells can be used. The counter electro motive force cell consists of one in which merely grids are used, having no capacity, the current always passing through in a charge direction. The plates are quite cheap, not having to be formed, and last a long while. These replace the use of resistance with an added advantage that the counter E. M. F. of these cells is never less than two volts, so that the regulation for small currents is better than with the use of resistances.

Small batteries may be charged in parallel or series parallel and discharged in series, usually with a resistance, or they may be charged from one voltage and discharged at another voltage.

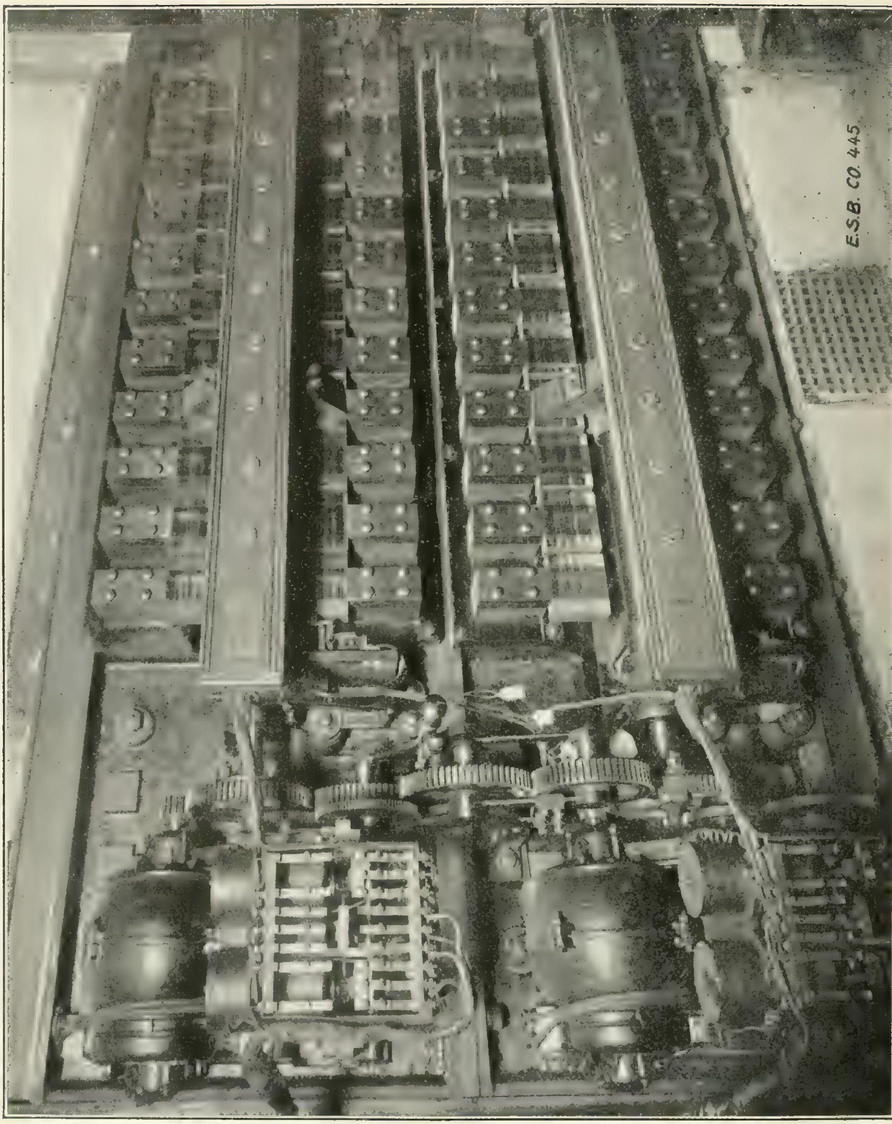
Large batteries are usually installed with boosters in series with the batteries. These boosters are low voltage generators, usually motor-driven, and their function is to make the battery voltage characteristic a straight line. On charge, the booster voltage is added to that of the line, on discharge (if used) to that of the battery.

End cell regulation is used on large batteries where discharges are constant in rate and run in capacity up to as high as 40,000 amperes per switch. As the battery discharges and the voltage of the battery falls, or tends to fall, additional cells are cut in by the switch, which is motor-driven in the large sizes, so that the supply voltage does not vary. End cells are usually used on lighting batteries as they are not made automatic.

In controlling batteries, the elementary protection given the circuits is about the same as for a generator; *i. e.*, switches, fuses or circuit breakers are installed, with, in many cases, a zero voltage or reverse current breaker, when it is not advisable to have the battery discharge, where compound or series generators are used, or in cases where it is not advisable to discharge back on a shunt generator.

Since current rates on large batteries run very high, the switching proposition is difficult when currents have to be handled as high as from 20,000 to 40,000 amperes. In such cases, remote control electrically operated switches are used.

Where the conditions of service call for rapid alternations of



Two High Speed Magnetic Control End Cell Switches
Maximum Capacity 20,000 Amperes Each

charge and discharge, an automatically controlled booster is connected between the generator and battery, the voltage of the booster being varied to secure the desired results. The device most widely adopted for automatically controlling the booster voltage is what is known as the carbon regulator. This regulator consists of two series of piles of carbon discs, arranged on opposite sides of the fulcrum of a lever, one end of which is subjected to the tension of an adjustable spring, while from the other end is suspended the soft iron core of a solenoid, connected into the generator circuit. The two series of discs are connected in series across the battery, while the field of the booster, or of its exciter, is connected into a circuit from the middle point of the battery to the middle point of the series of carbon piles. The whole arrangement forms a Wheatstone's bridge. When the load increases, pressure is put on one side of the carbon regulator unbalancing the bridge, allowing current to flow in the middle leg so that the booster voltage will build up in the proper direction to discharge the battery. When the load drops below the average, the spring overbalances the solenoid, which again unbalances the bridge, allowing current to flow in the middle leg in the reverse direction, the booster then adding its voltage to that of the line and charging the battery. The result of this is to maintain approximately a constant load on the generators, the variations being taken care of by the battery.

The two principal objects attained by this device is to have a booster quickly reversible, in response to load demands, and by the multiple effect of the Wheatstone bridge to a greater extent than is really necessary, as shown by the difference in pull on the solenoid. This is required to overcome the induction of the booster and reduce the time lag between the change in load and the battery taking care of the fluctuation, to an extremely small space of time.

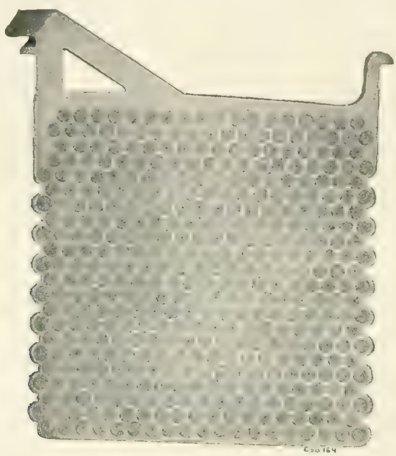
Several devices are used in connection with the carbon regulator so that the discharge of the battery can be controlled within well defined limits. When a battery is installed for the purpose of regulation and is discharging at its maximum rate, at a time of the heaviest load on the power house, it can be readily seen that if the circuit breaker on the battery should open, the load would suddenly be thrown on the station with an almost certain result that the generator circuit breakers would follow, thus cutting off service. By installing what is known as a current stop, which limits the charge and discharge of a battery to its overload limits, several valuable results are gained. One is that the battery takes care of the fluctuations of load until it reaches its limit, the generating equipment taking the rest, which is a slow change, thus allowing a smaller battery to be used to give the same results in load regulation. The action of the current stop on the charge side is also necessary for the better protection of the battery, as it avoids overcharging a battery at time of low load, thus increasing the life of the plates.

With the carbon regulator is also installed an average adjuster, which is a small motor suitably driven, which varies the

tension of the spring on the regulator. The action of this device is to keep the battery at the point of its maximum sensibility and relieve the battery from taking peaks which are not necessary, reserving all capacity for fluctuations.

The addition of these two devices to a carbon regulator allows a smaller battery to be installed to take care of a certain load fluctuation than would be possible without such devices.

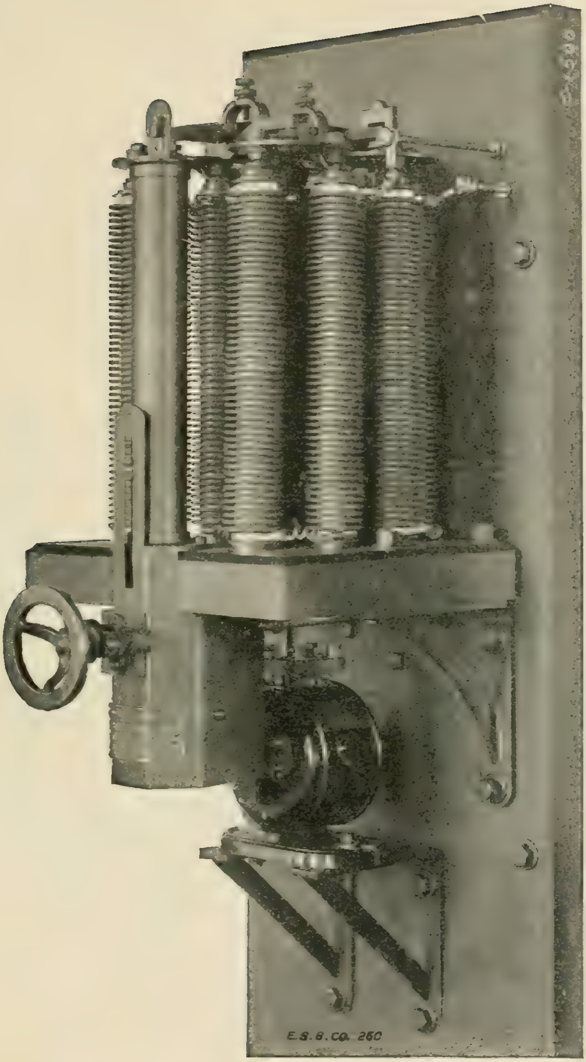
It is hard to make a division of the various uses for which storage batteries are installed, as it is very seldom that a battery is used for one purpose only. Generally speaking, batteries are used in two ways. In one the energy capacity of the battery is used as such, and in the other the energy capacity of the battery is utilized for short spaces of time, such as in taking care of rapid fluctuations for sudden demands for power. However, most batteries are installed for three or four different purposes and it is difficult to separate one function from another.



R Positive Manchester Plate

A charged storage battery represents potential energy, and therefore its uses are determined by the uses to which we can use energy, subject to the limitations of the battery itself. The capacity of any battery is limited, but the energy can be used in varying rates. For example, a battery may be discharged for many hours at a low rate, or at a high rate for a few minutes—it can be used on a steady or intermittent discharge, it can be used alone, or in combination with another source of current supply.

Perhaps the uses of storage batteries may be roughly divided into two classes, one in which the ampere hour capacity of the battery is utilized, the other in which the ampere capacity is the characteristic used. Both these classes would have subdivisions depending on whether the battery was aided by a source of current supply, or whether the energy was supplied by the battery only. A still further division would result in considering bat-



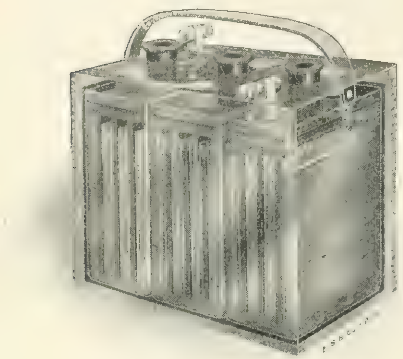
Carbon Regulator with Average Adjuster

teries used on regular cycles of charge and discharge, or if the duty performed was occasional, and all batteries would fall into two other classes, that of being portable or stationary.

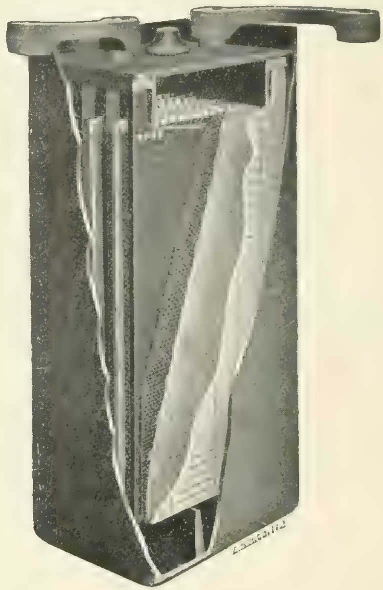
As for straight storage, probably the largest field at present for batteries is in vehicle work. In this case the battery is charged and has a certain amount of energy capacity, which is utilized in driving a motor car. The growth of the electric vehicle industry in the past few years has been wonderful and has been the result of improvements in motors, bearings, car designs, and mostly by improvements in batteries and in the life

and reliability of the later types. It is hardly necessary to go into this subject very deeply, as it is apparent on every side, especially in Cleveland, that the electric vehicle has a large part in the motor car industry. Proportionately the number of electric vehicles is increasing, compared to all other types of vehicles in use, largely so on account of the satisfactory mileage, now obtained by properly designed cars using first-class batteries.

This year has been marked by the introduction of a new type of lead battery which, for the same weight, has greater capacity than anything heretofore marketed. It also has a greatly increased life, thus reducing cost of operation and what is perhaps as important, lessening the time necessary in making battery repairs.



Phantom View Sparking Battery



Exide Cell for Vehicle Work

As said before, this is what is called straight storage, although there are some trucks on the market, where a battery is floated in parallel with an electric generator, driven by a gasoline engine, the battery in this case supplying the starting current or rather that portion of the starting current in excess of the normal load of the generator; this capacity being returned during periods when the truck is running free or standing still.

Train lighting is one of the largest fields for the storage battery and this field also is just opening. It does not require much to see that in the near future preventive laws will cause the disappearance of the lighting of trains by open flames. The loss of life in railroad accidents, due to the cars catching fire, is entirely due to the method used in lighting cars, and it is an open

secret that the railroads are looking forward to the day when electric lighting will be compulsory. For car lighting, electric lights are far superior to any others, not only as to safety, but also as to steadiness of the lights and better distribution, and the lack of odor and heat.

Car lighting is sometimes straight storage, that is, a battery is charged and kept in service until discharged, or until the end of the run. Two other systems are in general use. One where a car is equipped with a storage battery and a dynamo driven from the car axle, the latter being used to charge the battery and carry the load except during the time when the train is at a standstill or running at slow speed. The other system is a head-end system, in which a battery is installed in each car and a generator installed in the baggage car or on the engine; lighting the entire train except when the car or the engine is uncoupled.

A large field for batteries of the smaller type is in supplying current for the ignition of gas engines, either stationary or in the form of automobiles and motor boats. This also is mostly straight storage, although there are some automatic charging systems in which the generator is driven by the engine and the batteries used for starting and when the engine is not running, to supply lights. This latter point, that of supplying lights, is a comparatively recent development, due to the introduction of the wire type of metallic lamps and is practically standard.

Where an automobile is electric lighted, the same battery is usually used for both the lighting system and for the spark coil, although in some cases separate batteries are installed. The rapid growth of electric automobile lighting is evidence of its worth.

Stationary gas engines sometimes have a battery connected across a magneto, sometimes a portable battery, which is charged at some suitable source. The storage cell is rapidly replacing primary cells previously used for this work, as it is cheaper and more reliable.

In 1894, the first common battery in telephone service was installed, the first large one being installed the following January in Philadelphia, while the first battery with a full multiple switchboard was installed in June, 1896. Since that time the introduction of this modern type of telephone switchboard has been rapid so that there are in service considerably more than 100,000 cells of storage batteries used for supplying power for the talking circuits of telephones. The storage battery has also replaced in a great many cases the primary cells used for telegraph systems, at a considerable saving of expense.

In railway signal work, where reliability of service is indespensable, storage batteries are used in large quantities. These are sometimes installed so that they are charged from a central station, but in more sparsely settled districts portable batteries are used with great success, which are charged at some central point and distributed along the line, replacing batteries which are in turn taken back to be recharged. This is another instance

where a storage battery has been found cheaper and more reliable than the primary batteries which were first used.

In large alternating current central stations it is essential that current be kept on the field circuits of the alternators at all times. It is, therefore, necessary to have a reserve source of current in order to insure operation under all conditions, and storage batteries are used for this purpose. In almost all large central stations the normal function of these batteries is as a reserve to minimize the possibility of the station being left in an inoperative condition.

The same reasons which led to the installation of storage batteries on the field circuit of alternators has led to the extensive use of batteries for the operation of remote control oil switches. The modern oil switch is usually electrically operated either by a motor or a solenoid, and it is, of course, necessary that the switch should be capable of being opened at any time when it is necessary, without delay. The actual current required, of course, is not very great, but practically all first-class sub-stations are now equipped with a storage battery to be used for this purpose. With these batteries are installed charging sets, thus allowing them to be kept in first-class condition.

Storage batteries are also used on fire alarm systems and in wattmeter and instrument testing. This is particularly true where instruments are to be calibrated to a high percentage of accuracy, as the battery discharge is far steadier than any current obtained from a generator.

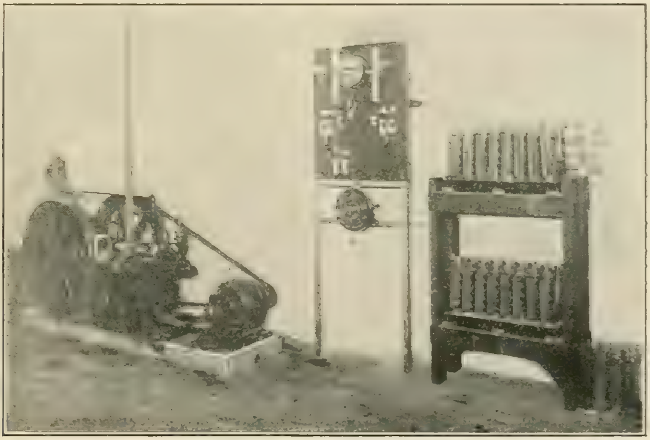
The lighting of detached residences and country places has always been perplexing and batteries are used, to a large extent, in these places in order to obtain a 24-hour service without operating a local generating plant for more than a few hours, as reserve, and for largely increasing the lighting capacity of the plant for short periods of time, such as receptions or other occasions, and because of the desire for steadiness of light on the part of owners of large homes.

As can be seen, such plants are quite large installations and a battery suitable for such purposes is rather expensive. Within the past couple of years the introduction of the low voltage Mazda lamp has allowed the use of storage batteries in many installations where its use previously has been prohibited. These installations, which are being installed in large numbers at the present time, are called low voltage plants and usually consist of 16 cells of battery with a small gas or gasoline engine-driven plant. The battery can be installed at prices ranging from $100 and up, depending on the size of the plant, and allow a small house owner to have the advantage of electric lights at quite a reasonable cost and with very little trouble in supplying power for the battery. The number of farm houses, which already have gasoline engines, is extremely large; in such cases the installation of the generator and the battery allows a farmer to have a great part of the work around the farm done by electric motors, and with scarcely any more expense allows him to have the convenience of the city in his home, no matter how remote from any electric generating

plant. It is sure that this low voltage house lighting has only begun to find a field for operation.

One other use for the storage battery is found in the lighting of yachts where, of course, modern methods of lighting are essential. These batteries run in large sizes, in some cases yachts have a capacity of as high as 140 16-candlepower carbon lamps burning continuously for three hours. It must not be overlooked that the submarine vessels in our navy are all equipped with storage batteries, which are used while the boat is submerged. These installations will run in extremely large sizes, the battery capacity being about 300 amperes for some three hours, the charging current being supplied by a generator driven by a gas engine, which is also used for propulsion while the boat is on the surface.

Electrically operated draw bridges on railroads are quite common, and as reliability of service is here most important,



Low Voltage Lighting Plant

storage batteries are installed. Most of these draw bridges are supplied with current from an alternating current supply, or by some form of gas engine-driven generator. Both of these sources of supply are apt to be irregular, and as a bridge must swing quickly and surely once the signal is given, dependance cannot be placed on the current supply alone. Then, too, the starting current for the motors is high, compared to the running current, the battery, of course, supplying the excess necessary, thus limiting the load on the generators. In the case of a gas engine plant, it is only necessary to run for a short time daily, or less often, to charge the battery, thus allowing current to be produced most economically both as to labor cost and engine load factor. Thus arranged, the actual operation of a bridge becomes a simple matter of using a controller for a motor, and in bridges, as in all other important work, the more nearly automatic the movements required for a given result on the part of the operator, the more reliable is operation.

When batteries are installed in order to relieve generating machinery from load fluctuations, some means are adopted to compensate for the voltage variations of the battery. If a battery is connected in parallel with a generator having a drooping characteristic, one in which the voltage drops in proportion to the load, a certain per cent of the fluctuations will come on the battery in proportion, as the drop in generator voltage is greater than that of the battery. This method is seldom used, as to secure good results the size of the battery is greater than if a booster were installed. If the battery were located at a considerable distance from the station, even if the generator had a straight line characteristic, the conditions would be far different. In this case the drop in voltage over the feeder or trolley wire would increase with increase of current; that is, the resistance of the line causes a loss in voltage at the point of the load. The battery, if properly located, now can take a greater proportion of the load on that section of the line, and in addition to relieving the power house, hold a higher voltage. This is the line battery and its installation on long trolley lines improves the line voltage, relieves the generators, to a large extent, from fluctuations, allows schedules to be maintained, and if properly designed, costs less than the copper which would be necessary to partially achieve the same results.

Generally, batteries taking care of fluctuations are equipped with boosters. For example, the battery installed at the Lukens Iron & Steel Works, Coatesville, Pa. Here the generating station, with an average load of 1,100 amperes, at 250 volts, was subject to fluctuations of 2,100 amperes when the mill motors were started. To supply the current, there were two 150-kilowatt and one 400-kilowatt machines. Here was installed a battery with a capacity of 1,600 amperes for taking care of the fluctuations, which resulted in the total load on the station being kept well within 10 per cent variation from the average, allowing the plant to be run with either the two 150-kilowatt machines, or the 400-kilowatt machine, leaving one or two machines in reserve. The economy due to steady load on the engines was, of course, marked.

A somewhat similar plant at the Edgar Thomson Works of the Carnegie Steel Co. is peculiar in that the battery was located at the point of greatest load, some 1,200 feet away from the power house, so that the feeder drop was compensated for. This battery has a capacity of 10,000 amperes for 20 minutes and 15,000 amperes momentarily, on a 250-volt bus. The load variations were very quick and ran from 4,000 to 20,000 amperes in very quick succession. This installation allowed the shutting down in regular service of a 2,000-kilowatt unit.

These and many other installations provide for a constant voltage for the load, which is of great advantage in electric railway and steel mill service. When, however, the motor load is starting of elevators, as in office buildings, hotels and the like, it is quite satisfactory to have the variable load taken care of at a varying voltage, and it is vitally important to keep the voltage of the lighting circuits constant. The booster in this case is

called a constant current booster, and is designed to be interposed between the generators and lights, and the power feeders.

The battery is connected across the latter. The booster allows a constant current of the proper average value to go to the power and battery bus. Any excess load is taken care of by the battery, while it also charges during periods of light or no load on the power bus. This system is extremely sensitive, and is one of the best from a battery standpoint, as the booster is quite small, in comparison to the plant, only carrying the average current for the load, instead of the battery current, which may be many times greater. Such batteries are also used to carry the night load, allowing the engines to shut down each evening, in addition to their daily work.

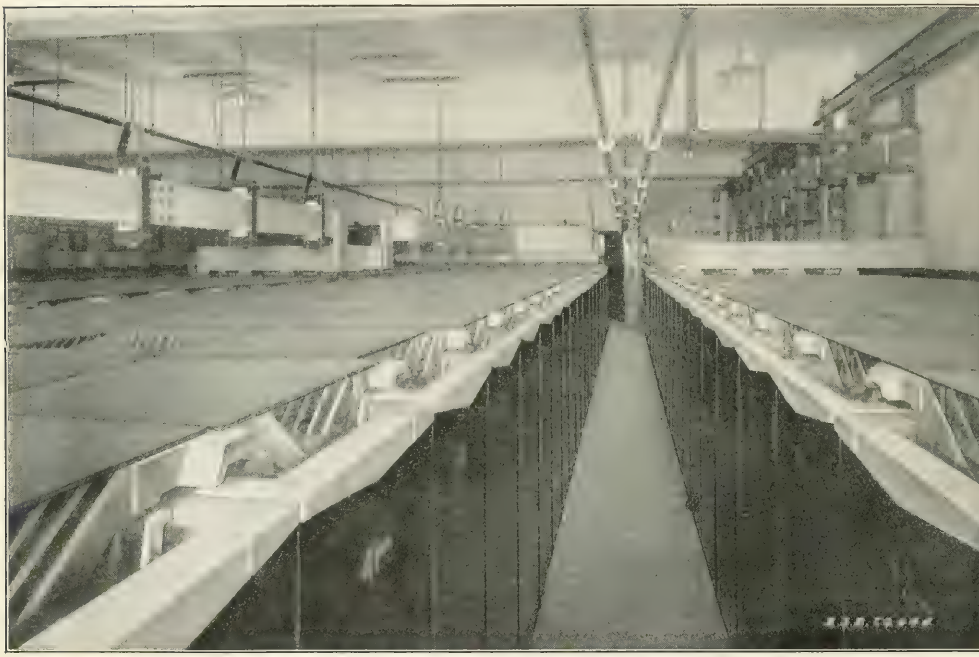
In most power houses and generating plants, the load is very uneven, that is, there is usually a peak load for a short time, when the station is worked at its maximum or overload capacity, while at other times the load usually runs from 20 to 40 per cent of the generating capacity. Storage batteries are installed in such cases to relieve the generators of this excess load, the charging being done at times of light load, thus tending to keep the average load more nearly constant. The benefits of this are apparent, since the fixed costs depend on station capacity, and not on product, therefore, to secure ideal results, a station should run continuously at full load. This is never realized, but any smoothing out of the load curve is a question of dollars and cents. Peak batteries are controlled either by boosters, adjusted by hand, though perhaps with automatic regulation in addition, or by the use of end cell switches on discharge.

It must be remembered that not only do peak batteries smooth out the load curve by absorbing the smaller fluctuations, and fill up the valleys and take off the hills on the larger charges, but they are also of great value in the case of sudden demands for power, especially in gaining time while spare units are being put on or off the line.

With the modern methods of purchasing power from hydroelectric and large steam generating plants, has come a large use of batteries, which cheapen the cost of power to the consumer, and allow rates to be made by the producer. An improvement in load factor for a large company allows the company to increase its revenue without additional capital expense. Since the rates charged are based on variable kilowatt hours supplied and on fixed charges, based on a maximum demand, the purchaser, by improving his own load factor, cheapens his fixed charge cost. This is so when the cost of the battery in capital and maintenance charges is less than the fixed charges and fixed expenses per kilowatt per year of the power company. There are many such situations in the west, where the installations are of large size, and they are giving great satisfaction; for not only is there the saving in yearly power cost, but the advantage of absolute continuity of service, which in many cases is of enough importance to warrant the installation. Particular reference may be made to the batteries installed by customers of the Commonwealth Edi-

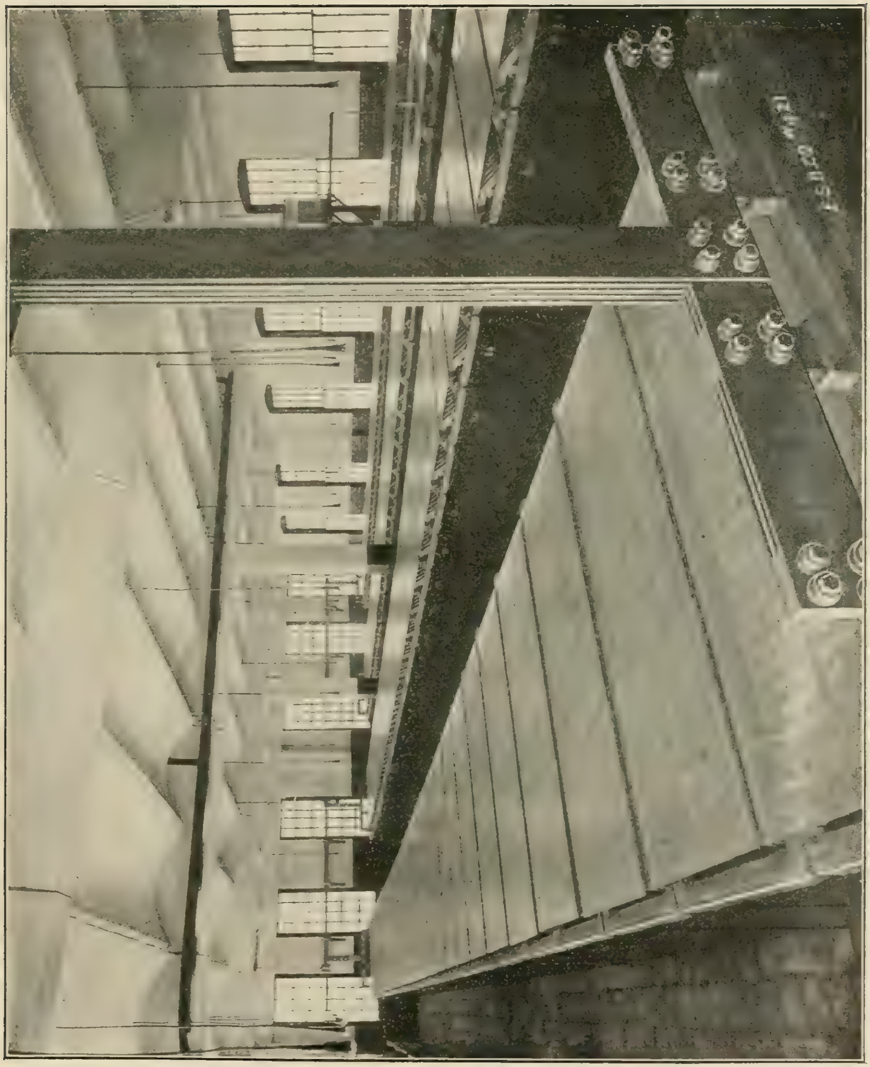
son Co. in Chicago, based on the foregoing system, and amounting to many thousands of kilowatts capacity.

In connection with this idea of continuity of service is a greatly increasing field for the storage battery. As the big supply stations grow, and their load factor improves, due to the development of the motor load, there has come a demand for constant service, particularly in the business districts of the large cities. How well the central stations fulfill their duties to their customers is known to but few—as most of their troubles are kept quietly to themselves. But aside from mechanical and electrical troubles, weather conditions worry the central station man. A recent snow storm with darkening clouds, caused an increase in load in New York City of from 100,000 horsepower to 166,000 horsepower in



Emergency Battery, N. Y. Edison Co., 150 Cells, Type 131 H. Exide.

10 minutes. Under conditions such as this, there is not time enough to get additional units ready for service at the power houses. Therefore, to provide for such cases batteries called emergency batteries are installed. These are of quite recent use. Their function is to take care of the unusual, and they are not supposed to be used in normal operation. In fact, they are considered a good investment if they are never used. For this work a new type of plate, a pasted one, has been developed. This gives greatly increased capacity over plates used heretofore for the same space, allowing a great saving in first cost of buildings, which is of prime importance, when it is considered that they are



First Floor Battery Room, Indiana Steel Co., Gary, Ind.

usually installed in those parts of cities where real estate is most expensive.

As to their size, one was recently installed in New York, in which each cell weighed 6,900 pounds. The latest of these being installed in Baltimore consists of 152 cells, each of 133 plates with four 13-point end cell switches. Its capacity is 17,300 amperes for half an hour, or expressed otherwise, this battery would light 240,000 25-watt Mazda lamps for 20 minutes. The tanks are approximately 4 x 2 x 6 feet, the total weight of the battery being 1,079,200 pounds.

Batteries of this type represent the latest development of storage battery engineering. To compare the old with the new, in the same tanks, the six-minute rating of the old and new plates is approximately as 14,440 amperes to 36,000 amperes. With the new plates has been developed high speed magnetic controlled end cell switches, which operate at very high current densities, with a maximum of 40,000 amperes, and driven at such speed that the brushes can go from one end of the switch to the other in a few seconds. In fact, there are many station operators who have thought for months that the switches were too fast.

Modern design is to bar from the battery room all wood, and to this end, the latest innovation is to mount the battery tanks on high porcelain insulators about 8 inches in diameter and a foot high. On this is placed an oil insulator, which ends troubles with battery tanks, due to electrolysis through grounded tank linings. Wooden tanks are still used, but constant effort is being made to replace them with earthenware, and some day this, too, may be adopted in one form or another.

In the handling of heavy currents, such as are used in emergency work, and in batteries in steel mills, it has been found necessary to pay particular attention to the holding of the copper conductors firmly in place. Standard practice is to bolt them firmly top and bottom, and to securely anchor everything. It is no easy problem to hold two parallel pieces of copper, a few inches apart, in position when they are carrying currents of some 40,000 amperes in opposite directions, but it is done. It is this constant development of details which has made the storage battery the widely used piece of apparatus it has become.

It scarcely seems right to talk of using storage batteries on alternating current systems, but this is one of the greatest fields, especially in lines of heavy work. Where alternating current is used for distributing energy only, the problem is not very difficult. Such systems usually convert alternating current into direct current for use, and the battery is installed on the direct current side. There are very many methods by which this may be handled, usually through a rotary connector with either a direct or alternating current booster in series. At the well known installation of the Indiana Steel Co., at Gary, Ind., this is effected by means of a "split phase" rotary, which is a self-contained unit, to which the battery is connected on one side, and the alternating current supply to the other. By a special exciter connected to the generator leads through series transformers, the direct current volt-

age of the rotary is varied so that the fluctuations of the load are taken by the battery through the converter. This plant is an enormous one. With half the battery installed, discharges of 25,000 amperes are taken care of at 200 volts, though this is greater than the capacity of the rotaries used, which are of 2,000 kilowatts, though they can handle a momentary overload well up to 4,000 kilowatts. The success of the Gary generating plant and battery installation deserves a tribute to the engineering skill and courage, which has been used from its inception.

Some Recent Improvements in Electric Motor Control

By Claiborne Pirtle

Switching Devices.

Any electrical control system must be based fundamentally on one or more forms of switching devices. The simplest switching device is touching and separating the wire conducting the current of electricity and examples of this simple form are the telegraph key and the telephone switch, operated by taking down and hanging up the receiver. For any except very small currents a larger contact area must be provided, so the knife blade switch and sliding contact were devised when the advent of the dynamo made available larger currents at higher voltages than had been obtainable from batteries.

The electric current was first used solely for lighting and these devices did very well for the relatively small currents at the relatively low voltages then used. When it was found that the dynamo used to convert the mechanical energy of a prime mover, such as the steam engine, into electrical energy could also be used to reconvert this electrical energy into mechanical energy the electric motor came into existence. For the small sizes first produced the simple knife switch and sliding contact were successful and are still used, although not entirely satisfactory.

Remote control or control of electric motors from a distance was first proposed for elevator service and was effected through the agency of magnetically operated switches. Eickmeyer, in 1891, devised such a system and his work was followed by Sprague, who perfected a system during the years 1894 to 1896, and a great many of these Sprague Elevator Magnetic Controllers are still in operation. About this time, 1896, the dirt and noise of the steam engines pulling the trains on the elevated roads in Boston, Chicago and New York caused a demand for electric operation of these trains. Single street cars electrically driven had become the standard and displaced not only the horse-drawn car, but also the cable roads. To adapt the electrically-driven street car for operation in trains to meet this demand, some system of remote multiple control was necessary, because every car or every other car had to be motor-driven and all had to be controlled from the head end of the first car. Sprague developed such a system and the trains on the Boston Elevated were operated electrically in 1898. Since then automatic magnetic switch control has been very widely applied. It is being predicted that automatic magnetic switch control will become the standard and will eventually displace all other forms.

Advantages of Automatic Starting.

Just as steam must be admitted slowly to an engine starting cold and from rest so the current input to a motor must be limited during acceleration. This is accomplished by inserting resistance in the motor circuit and gradually cutting it out as the motor comes up to speed. This resistance is designed to remain in circuit only during the short time of starting. If the resistance is cut out too slowly, it overheats and is liable to burn out. If cut out too fast, too much current is allowed to flow through the motor with consequent electrical and mechanical strains and danger of burn-out, grounding, and commutator trouble. With the ordinary manually operated starter the rapidity with which the resistance is cut out is subject to the personal equation of the operator and is not done properly except by chance. Operators are almost invariably either too careful and slow and so overheat the starting resistance, or are too impetuous and fast and overload the motor. The motor should be accelerated reliably with a fixed maximum current input, this maximum current input being fixed by the electrical engineer and not by a careless or ignorant operator. This gives the following valuable results:

First.—Motor may be invariably brought up to speed with maximum safe acceleration, thus assisting in maintaining the output at a maximum.

Second.—Delays due to both electrical and mechanical breakdowns are greatly reduced by limiting the current during acceleration and reversal. This, of course, has an important bearing on both output and maintenance cost.

Third.—Acceleration of the motor by means of a controller, which automatically interprets operating conditions, leaves it to the operator to simply push or pull a lever, or push a button, as far as starting or stopping is concerned. Consequently, less skilled workmen may be employed or where skilled workmen are necessary they can devote all their skill to their work. The combination workman and motorman becomes a workman pure and simple.

There have been a number of automatic acceleration control systems that were successful in relieving the workman of this responsibility and effecting the results above mentioned, but none of them have been entirely satisfactory. Some merely limit by a dashpot the time of cutting out the resistance and act irrespective of the load on the motor and these are little better than manual control except that they provide for operation from a distance. Others will not operate if the voltage is too low or too high, but the great disadvantage of all of them is complication.

The diagram of connections of such a controller is a mass of lines, including main circuits and shunt circuits, main contacts, auxiliary contacts, relays, and from six to a dozen or more interlocks or control circuit contacts or butterflies. Such a wiring diagram cannot be understood by an ordinary "monkey wrench electrician". Special knowledge gained only by special training or extended experience is necessary.

Excessive delays are experienced by the short-circuiting of control circuit wires and contacts or operating coils subjected to full line voltage, wound with wire as fine as a hair.

Knowledge and skill are required to quickly diagnose the trouble with such a magnetic controller and make the necessary adjustments or repairs.

Therefore, the greatest improvement which can be made in magnetic controllers lies in the direction of the elimination of complication.

The Improved System.

The company with which I am connected, as a result of long continued research and experiment, is able to announce the perfection and standardization of magnetic controllers and motor starters "reduced to their lowest terms".

In this simplified magnetic controller there are no control circuit contacts or butterflies carried by the reversing switches or the resistance switches.

The switches are caused to close in an orderly sequence (that is, the second switch cannot close until the first switch is closed, the third switch cannot close until the second switch is closed, and so on) ; this result being obtained without the use of control circuit contacts or butterflies.

The main switch or reversing switches are interlocked against failure of any of the resistance switches to open, thereby preventing application of current till all of the accelerating resistance is in circuit with the motor, this interlock being also obtained without the use of control circuit contacts or butterflies.

The operating coils of the resistance switches instead of being wound with wire as fine as thread are wound with wire or copper strap as heavy as the series windings of the motor, and instead of being subjected to full line voltage of, say, 220 volts, each coil is subjected to an insulation strain of a fraction of a volt.

The operating windings of the resistance switches are in fact in series with the motor, and the characteristics of the resistance switches are such that the switches remain closed till the motor current has been reduced to practically zero. There is, therefore, no arcing at the contacts of the resistance switches, and no need of blow-outs or other arc-rupturing devices on these switches.

Each resistance switch, in addition to its functions as a switch, embodies the functions of a series relay, by means of which the maximum accelerating current may be fixed at will. Automatic current limit acceleration is, therefore, obtained without the use of one or more separate relays responsive to the motor current.

Plate No. 1 is a cross section of one of these new series wound switches. This switch comprises a "C"-shaped magnetic frame *A*, which is provided at its upper arm with a movable plug *B*, and at its lower arm with an adjustable annular plug *C*. *E* is the plunger, which is provided at its lower end with a steel extension *F*, and at its upper end with a contact maker *G*, which is adapted when the switch closes to make contact with a pair of

laminated brushes *H*. *I* is the magnetizing winding adapted to be connected in series with the motor to be controlled.

A New and Remarkable Switching Device.

This switch possesses the following remarkable characteristics:

If a current lower than a certain predetermined value is passed through the winding, the switch will close and will be held closed till the current is reduced to practically zero.

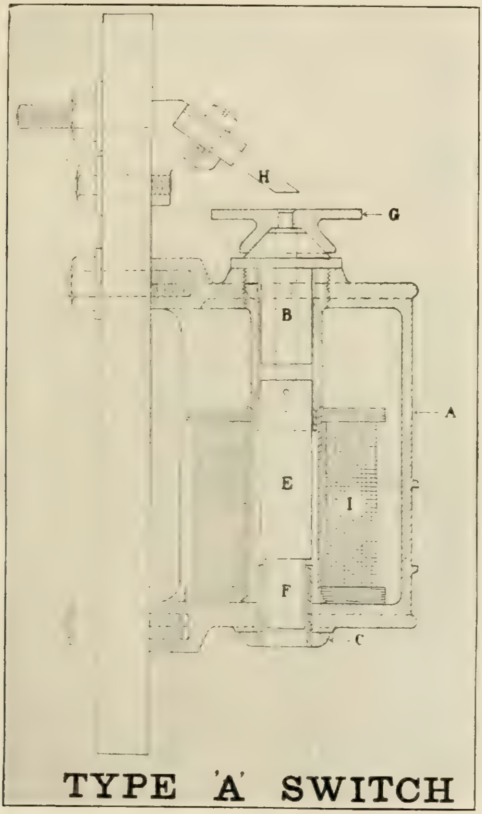


Plate 1

If a curent above a certain critical value be sent through the winding, the plunger of the switch instead of going up and closing the switch, actually tends to go the other way. In other words, the switch is held open until the current has been reduced (by the speeding up of the motor) to the predetermined accelerating value, and when this value is reached, the switch will automatically close.

The value of current below which the switch will close and above which the switch will lock out or refuse to close is adjust-

able through a wide range. Each switch is therefore a combined switch and series relay, the combination making a very simple and sturdy unit with a very wide range of application to electric motor control.

The curves, plate No. 2, show the operating characteristics of one of these switches. The abscissas of these curves represent air gaps between the lower end of the plunger and the upper end of the adjustable plug in fractions of an inch. The ordinates of these curves represent ampere turns in the winding. If the winding had but one turn, the scale would read amperes.

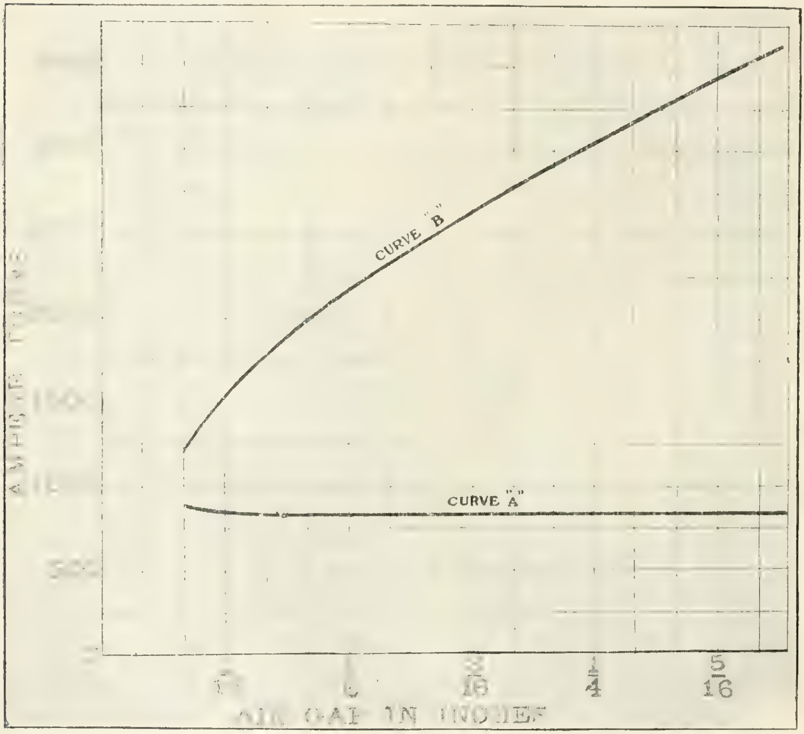


Plate 2

Curve *A* shows the minimum ampere turns at which the switch will close. You will observe that this curve is substantially a horizontal line through the entire range of adjustment, so that the minimum current at which the switch will close remains substantially constant.

Curve *B* is the operating or closing curve.

The switch will close at any value of current between the curves *A* and *B* for the corresponding adjustment. If at any point in the range of adjustment the motor current is greater than the ordinate of the curve *B* indicates, the switch will not close.

but will lock out till the current has dropped to the value shown by the curve at any point.

Explanation of Operation.

Now as to just how and why this switch operates in the way it does, we will disregard fine spun theory and review the matter from the standpoint of applied engineering, and from this standpoint an explanation, which will answer the purpose, can be given.

Referring to the cross section of the switch, you will see that the operating plunger lies between two poles—one the plug in the upper arm of the frame, and the other the annular face of the adjustable plug in the lower arm of the frame. The lower end of the plunger is provided with an extension passing into the lower plug. Considering the path of the magnetic flux through the magnetic circuit of the switch practically all of the flux set up will pass out of the upper end of the plunger in a direction at right angles to its upper face. As you very well know, this flux will set up an upward pull on the plunger tending to lift the plunger and close the switch, and the amount of this pull will be proportional to the square of the flux density.

Looking now at the lower end of the plunger, it is seen that the magnetic flux can enter it by two paths. One of these paths is from the frame and into the extension of the plunger. Most of the flux through this path enters the plunger horizontally and hence it produces little magnetic pull in a vertical direction. The other path of the flux is directly into the lower end of the body of the plunger through the shoulder next to the extension. The direction of this flux is substantially vertical and therefore produces a magnetic pull tending to move the plunger downward. The plunger is then subjected to two opposing magnetic pulls. Considering again the lower end of the plunger, as mentioned before, the flux enters it through two paths, and, of course, the flux divides in inverse ratio to the reluctances of these paths. When the magnetizing force is high (in other words, when the current in the winding of the switch is high), the extension of the plunger is practically saturated and therefore offers a high reluctance, and consequently a larger proportion of magnetic lines pass through the air gap vertically and into the lower shoulder of the plunger, and the downward pull on the plunger is high.

When the current in the winding of the switch is lower, a larger proportion of the flux passes through the extension and a less proportion passes vertically into the lower shoulder of the plunger. Consequently, the downward pull on the plunger is less.

If the current in the winding of the switch is above a certain value, the downward pull on the plunger plus the weight of the moving part of the switch is greater than the upward pull, due to the flux passing out of the upper end of the plunger, and the switch cannot close. With current lower than this, the upward pull is greater than the downward pull plus the weight of the moving parts and the switch will close.

The critical value of current below which the switch closes and above which the switch will lock out or refuse to close is

adjusted by adjusting the lower air gap by means of the adjustable plug.

It must be apparent now that this switch is a self-contained switch and series relay.

Diagram of Connections.

Plate No. 3 shows the diagram of a simple starter connected with a shunt motor. The knife switch closes the motor circuit through the coil of the first resistance switch *S1* and the resultant current flow being greater than the value for which the switch is

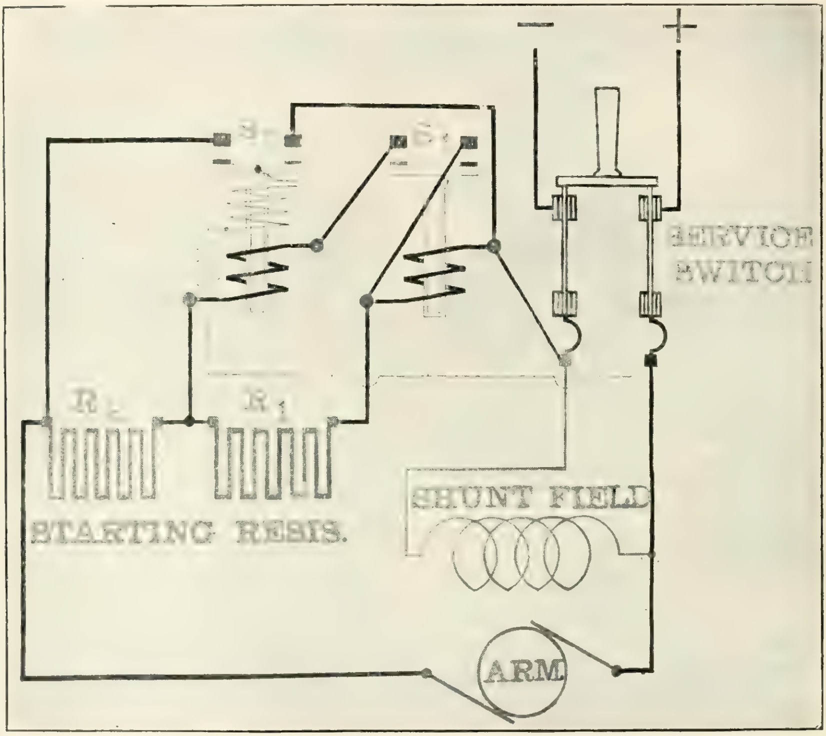
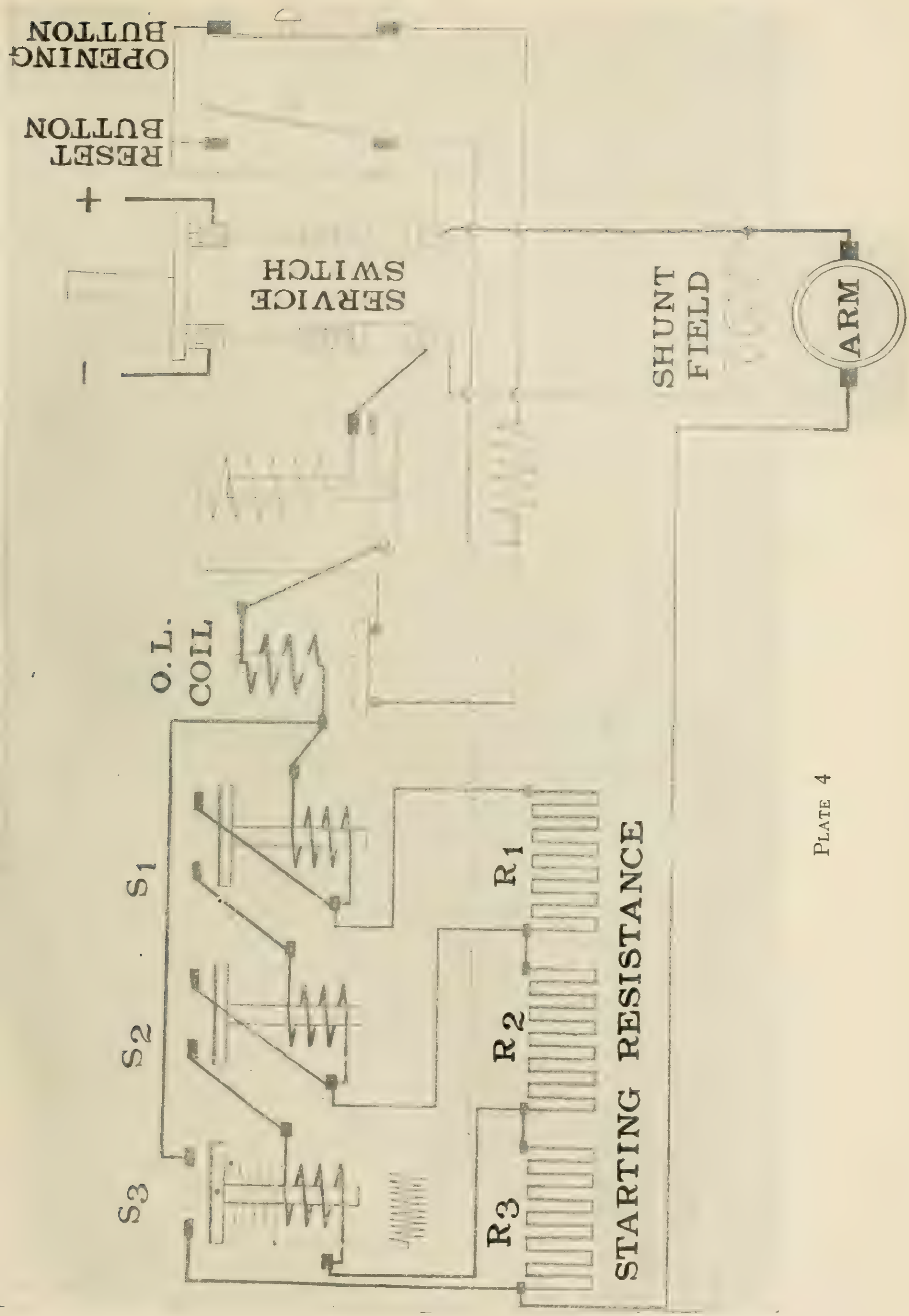


Plate 3

adjusted, the switch will lock out and will not close until the current has been reduced by the speeding up of the motor. When switch *S1* closes, it closes the circuit through the winding of switch *S2* and cuts out of circuit resistance *R1*, which permits a current flow sufficient to lock out switch *S2*. Switch *S2* will then not close till the current has fallen again, due to the further speeding up of the motor. Finally switch *S2* closes, cutting out all of the starting resistance, and short-circuiting the operating coils of both itself and switch *S1*. Also when switch *S2* closes, its little holding coil is energized, which prevents it from opening and both the operating coils being short-circuited, switch *S1* opens.



OPENING BUTTON
RESET BUTTON
+
-
SERVICE SWITCH
SHUNT FIELD
ARM
O. L. COIL
S_1
S_2
S_3
R_1
R_2
R_3
STARTING RESISTANCE

PLATE 4

When it is desired to stop the motor, the knife switch is opened. It will be observed that since switch $S1$ locks out when the knife switch is closed, the number of acceleration points is one more than the number of magnetic switches used.

In the case of plate No. 3, the number of switches is two and the number of acceleration points three. It is evident that more automatic acceleration points can be obtained by adding more switches.

In manually operated starters, the resistance is divided into a considerable number of steps, not because they are necessary as acceleration points, but to keep the voltage drop between steps low enough to prevent destructive arcing.

Each size E. C. & M. automatic motor starter is furnished so that a choice can be made in the number of acceleration points dependent upon the service. A small motor does not require as many acceleration points as a large motor and a motor driving a load having little inertia does not require in starting as many acceleration points as the same size motor in starting a load having large inertia, such as a punch press with heavy flywheel.

Advantages of the New System.

E. C. & M. automatic motor starters start the motor always in the shortest possible time consistent with the load and its character. For instance, a 10-horsepower, three-switch starter would start a punch press with heavy flywheel in 10 to 12 seconds and would start a motor belted to a machine tool with the clutch out in about one second. The operator needs only to open and close the knife switch and the starter will do the rest, always protecting the motor by limiting the current input during starting and timing the period of starting to the load and its character. It is also evident from plate No. 3 that the knife switch can be put at any convenient point so that the operator does not have to go to the starter to start and stop the motor.

Remote Control.

Plate No. 4 shows an E. C. & M. automatic motor starter arranged with circuit breaker and remote control features. The remote control can be effected either by push buttons, as shown, or by float switch or pressure gage. In this case, three acceleration switches are shown and it will be seen that when switch $S3$ closes, current is cut out of the operating coils of all three switches and switches $S1$ and $S2$ open. In this form of starter the closure of the knife switch does not start the motor, but simply closes the circuit from positive through the normally closed opening button, through the preventive resistance, through the contacts of the overload coil, through the operating coil of the shunt wound circuit breaker switch to negative. The preventive resistance does not allow a current flow sufficient to close the shunt wound circuit breaker switch, but only enough to hold it in the closed position.

Now, if the normally open reset button is pushed, the preventive resistance is momentarily short-circuited and full line voltage applied to the shunt wound operating coil of the circuit

breaker switch, which closes instantly. When the pressure is taken off of the reset button, sufficient current flows through the opening button and preventive resistance unit to maintain the circuit breaker switch in the closed position, but when the opening

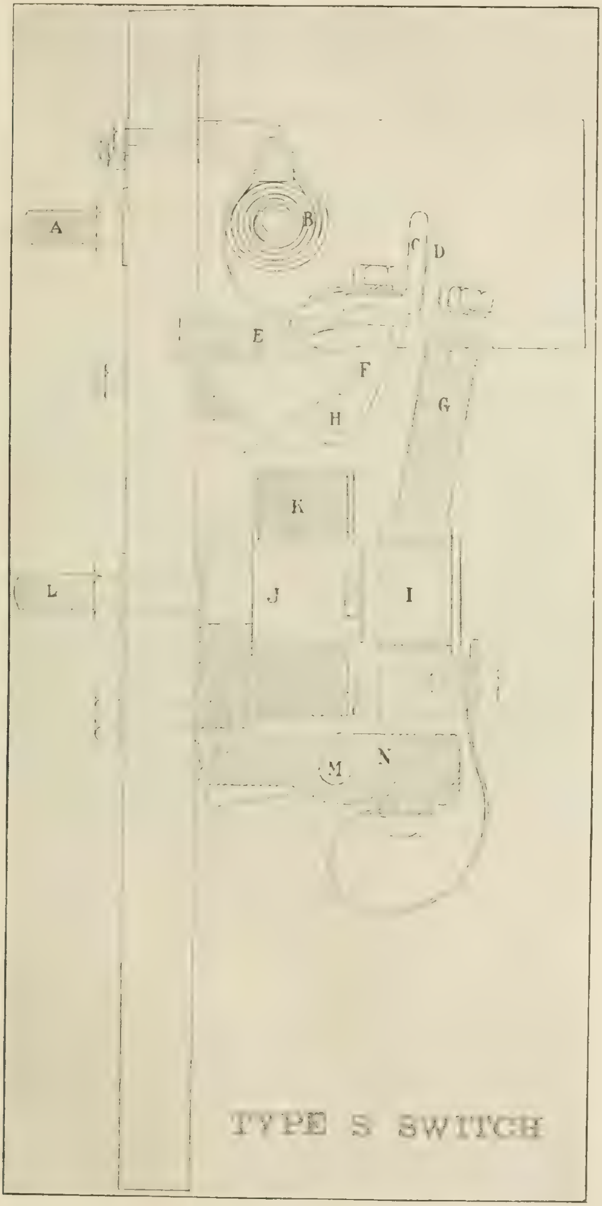


PLATE 5

button is pushed, this current is interrupted and the circuit breaker switch opens instantly.

It is evident that as many opening and reset buttons as desired may be used, the reset buttons being connected in parallel and the opening buttons in series. If the current at any time rises above the value for which the overload coil is adjusted, its plunger will rise and interrupt the current through the operating coil of the circuit breaker switch, which will open instantly.

To start the motor again, it will then be necessary to push the reset button. When the circuit breaker switch closes, the motor is started and accelerated, as previously described, upon closure of the knife switch in plate No. 3.

The type *S* shunt switch is a fit companion to the type *A* series switch since it is simpler and more efficient than other shunt

PLATE 6

operated magnetic switches. Plate No. 5 is a cross section of this switch, which is composed of only a few sturdy simple parts easily assembled and disassembled. The path of the current through this switch is from stud *A* through blowout coil *B*, through contacts *C* and *D*, through arm *G*, through frame *N*, and out stud *L*. *K* is the shunt wound operating coil, mounted on the fixed core *J*, there being no sliding core or plunger to wear and stick. The main arm *G* rotates about the pin *M*, and the auxiliary arm *F* about the pin *H*, the spring *E* pressing arm *F* forward against the stop when the switch is open. In closing, the contacts *C* and *D* come together with a rolling motion, contact being made first on the tips and finally on the heels, as seen in plate No. 5, which shows the switch in the closed position. In opening, the

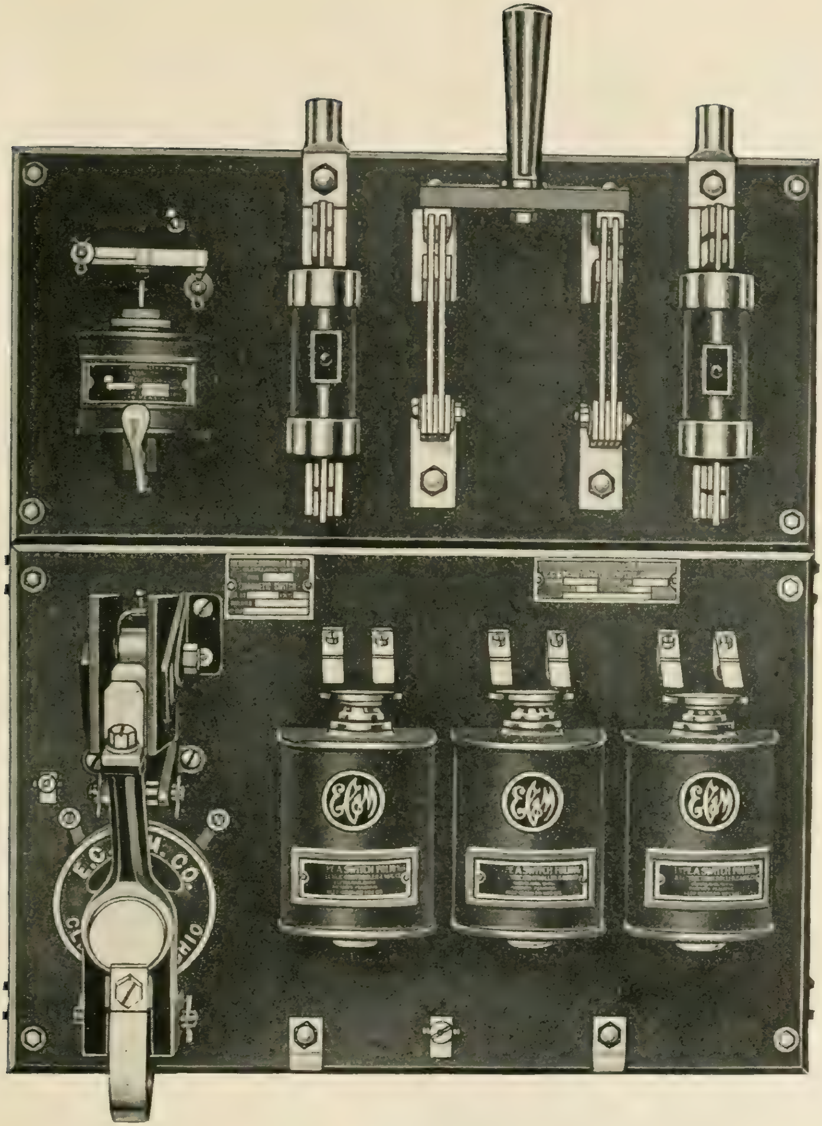


PLATE 7

reverse of this action takes place, so that the arc is always taken by the tips of the contacts, leaving the heels clean and bright for carrying the current. It will be seen that the points *M, H* and *C, D* form almost a closed toggle when the switch is closed and this toggle multiplies many times the 15 pounds push of spring *E* to effectively separate contacts *C* and *D,* if there is any tendency to stick or weld in the closed position, due to heavy overloads.

The contacts of type *S* switches, which are the only parts

requiring regular renewal, show remarkably long life even in very severe duty. At the plant of the Lackawanna Steel Co., the contacts of these switches on a motor driving a reversing mill table get 6,000 to 6,500 operations every day, including Sundays, at full or more than full load and are renewed once every five months. This is at least 900,000 breaks at full load before renewal of contacts. The ordinary circuit breaker, with which you are all no doubt familiar, must be practically rebuilt after 5,000 to 6,000 operations and the carbons will last for only a very few hundred operations. The plug *I*, which fits loosely in arm *G*, serves to cushion and prevent hammer blow both in the closing and opening of the switch, and accounts, to a great extent, not only for the long life of the contacts, but also for the practically neglectable depreciation of the switch as a whole.

Commercial Forms of the New Type Starters.

Plate No. 6 shows the simplest form of E. C. & M. automatic motor starter, called the form *A*, and when connected to

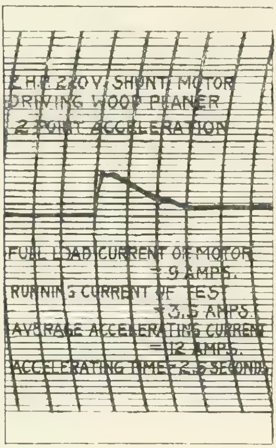


Plate 8

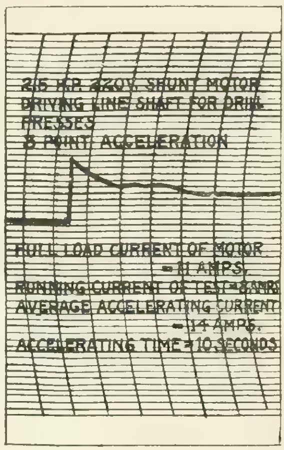


Plate 9

the supply mains through a knife switch, this starter will function, as described in connection with wiring diagram, shown in plate No. 3.

Plate No. 7 shows the form *ASBK*, which provides automatic acceleration overload circuit breaker, remote control, no voltage release and service knife switch with enclosed fuses.

This starter functions in accordance with wiring diagram, shown in Plate No. 4. These starters are also furnished in various forms simpler than the form *ASBK*, where one or more of the features obtained with this form are not required.

Performance Curves.

Plate No. 8 is a curve taken on a curve drawing ammeter, showing the action of the form *A* starter on wood planer. This

starter had only a single type *A* switch, which with the knife switch gave a two-point acceleration, as is clearly shown in the curve. This motor, of course, starts under light load so that the accelerating time is short, only two and one-half seconds, and the one switch starter gives a good acceleration curve.

Plate No. 9 shows the curve of approximately the same size motor starting a line shaft. This starter had two type *A* switches, giving a three-point acceleration. The minimum load on this motor is three quarters full load and in starting combined inertia and friction is met so that the acceleration time is ten seconds. A one-switch starter would not have given satisfactory acceleration on this character of load.

Plate No. 10 shows the same size motor and one-switch starter starting a circular saw. This is another case of starting under light load and the one switch starter meets the conditions nicely.

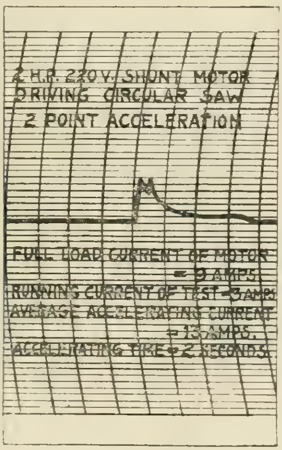


Plate 10

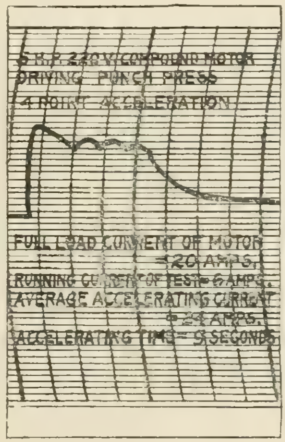


Plate 11

Plate No. 11 shows a three-switch starter, giving four points of acceleration, starting a punch press with a very heavy flywheel giving a high inertia load in starting. The accelerating time in this case is nine seconds and the four points of acceleration are none too many. This starter replaced a manually operated starter of the one-minute type. Even with this special manually operated starter the flywheel was so heavy in proportion to the size of the motor that it took two men to get the press going. One would handle the starting box and the other would help by turning the flywheel as fast and as long as he could by hand. The electrician was the only one who could successfully handle the starting box. With the E. C. & M. automatic starter no hand help is required and any one can start the press; any workman wishing to use the press simply closes the knife switch to start and opens it to stop.

Plate No. 12 shows a 100-horsepower reversing controller composed of type *S* switches for reversing, and type *A* switches for acceleration. This controller is designed for the severe duty of steel mill roller table operation, where the motor under full load must be reversed from full speed in one direction to full speed in the other direction in from three to five seconds, and the switches are required to operate 5,000 to 7,000 times a day. This controller absolutely limits the current input to the motor at all times to a predetermined amount and protects not only the motor but itself against the carelessness or ignorance of operators. Steel mill operators are paid on a tonnage basis and will get all the speed they can out of machines irrespective of how badly they mistreat the machine or its driving motor. Therefore, controllers in this work must not only be fool-proof, but must be proof against intelligent mistreatment.

In all the plates shown, you will have noted the extreme simplicity and absence of small delicate parts, and it is this sim-

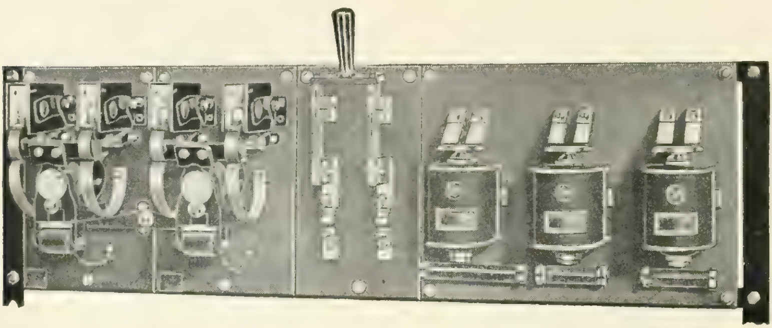


Plate 12

plicity as well as the superior operation of this new type of control that is causing the rapid adoption of it by users who are familiar with other types.

Protective Features.

If a direct current, shunt or compound wound motor loses its field, the motor will run away unless the circuit breaker opens and many wrecks have occurred through the breaking of the shunt field. The shunt field circuit may break while the motor is idle or while it is accelerating, or while it is running, and a competent shunt field protection should cut the motor off the line no matter when the shunt field opens. A unit piece of apparatus like the pressure regulator shown in plate No. 20 is furnished for shunt field protection. It is composed of a type *S* switch, a little relay, and a push button, and will instantly cut the power off the motor if the shunt field is broken during acceleration or while running. If the shunt field is broken while the motor is idle, with this protective device it will be impossible to start, since the type *S* switch

will not close. This device is, of course, applicable to any starter, whether manual or automatic, and irrespective of by whom made.

When the starters are furnished with shunt field rheostat for adjusting the speed of a motor by shunt field control, an electrical interlock is furnished so that the motor cannot be started with a weak field. The field rheostat must be brought to the off position, insuring full field strength before the E. C. & M. automatic motor will operate.

Dynamic Braking.

The operation of many motor-driven machines requires that the motor and machine be brought to a prompt stop when power is cut off. The time of drifting to a stop could not be tolerated. Stopping buttons are often put about a motor-driven machine or along a motor-driven line shaft with the idea of promptly cutting off the power in case of accident, and thus save the life and limb of employes. The motor armature, however, has considerable inertia and also the driven machine often has, so that a prompt stop is not effected and men are crippled and killed by the moving machinery even after the power has been cut off. The motor itself may be used as a most effective brake when controlled by an E. C. & M. automatic starter, equipped with the dynamic braking feature.

The same machine used to convert the mechanical energy of a prime mover, such as a steam engine, into electrical energy, may be used to reconvert this electrical energy into mechanical energy. In other words, the electric generator in the power house and the motor in the shop are in all essentials the same. After power has been cut off from a motor, it is driven by its own momentum, and the momentum of the machine it has the moment before been driving. If now it is connected as a generator so as to pump current through its own resistance it will convert the mechanical energy stored up in the momentum of the machine into electrical energy, which will be expended in the resistance, and this will bring the motor (now a generator) to a prompt stop. The type *A* switches, which act in starting to automatically accelerate the motor, act in stopping by dynamic braking to automatically decelerate the motor so a quick stop to absolute rest is the result.

The E. C. & M. type *A* series switch being a rugged, simple self-contained switch and series relay improves and simplifies not only the starting of motors, but also their control for almost any service. Several eminent engineers have declared that this series switch is the most important development since the advent of magnetic switch control. A number of the largest operators in the country agree that this series switch will do away with 90 per cent of the troubles and objections to magnetic switch control.

Visiting Party in Front of Lorain Steel Co.'s Plant

Society Notes

ANNUAL OUTING

The annual outing of the Society was held Tuesday, Sept. 12, as announced to the members in the official bulletin. The day could not have been more beautiful and the weather added much to the enjoyment of the occasion. The Society assembled in the Chamber of Commerce and at 1:30 P. M. started, via the Lake Shore Electric railroad, for Lorain. Three special cars had been provided and they were well filled with members and guests of the Society. The actual attendance was 143, which included numerous men prominent in the affairs of Cleveland, who were not members of the Society.

Upon arriving at Lorain, the party divided into two groups, one of which was to visit the plant of the American Ship Building Co., and the other to inspect a fast unloading plant, recently constructed for the B. & O. railroad by the Brown Hoisting Machinery Co., of Cleveland. Those who visited the ship yard displayed much interest; they were welcomed at the gate by officers of the plant, who courteously directed their movements and pointed out the items of especial interest. An oil barge was on the stocks and the visitors were permitted to climb to the deck and obtain a view of the interior construction. Mr. Frank La Marche, of the American Ship Building Co., took a personal interest in arranging the trip to this plant. At the B. & O. unloading plant, like courtesy was shown and the plant was put through the motions of unloading for our benefit, although there was no ore at hand to unload.

After visiting these plants, the party united and continued the trip to the plant of the Lorain Steel Co. This plant proved by far the most impressive object to the engineers. They were met, as before, by guides and officers of the company, and dividing into small groups, proceeded to view the works. They first went to the docks, where the ore was being unloaded, thence to the blast furnaces, the open-hearth, converter and rolling mills, successively. The blowing engines used at the blast furnaces excited much interest, particularly the steam turbine directly connected to a centrifugal fan. This recent installation is typical of the progressive spirit, which has always existed at Lorain. The plant is always up-to-date and there was much praise of the neatness and order which everywhere prevailed.

The tube mills proved more attractive, if such a thing were possible, than anything else encountered on the trip; at any rate, the members were so absorbed in watching the red hot skelp being converted into pipe that it was with difficulty the committee in charge drew them away in time for the return cars to Lorain.

View of the American Ship Building Co.'s Yard and Plant

Mr. F. H. Beebe, assistant engineer of the National Tube Co., was especially active in entertaining the visiting engineers.

Arriving at the Hotel Lorain, a sumptuous meal was found awaiting the hungry engineers, and the tube mills were temporarily forgotten. At the close of the meal, a short business session was held, which is reported in the minutes, and the party started for Cleveland on schedule time. The return home was without incident other than an interested comparison of notes and a general regret that the day had been so short.

If the success of an outing may be judged by the apparent interest of those in attendance, the program committee has reason to feel proud of its effort. There must, however, be noted in closing, a genuine regret that the Detroit Engineering Society had not joined with us at Lorain, as invited. They, too, could have enjoyed the outing and made it doubly pleasant for both Societies. We hope some other occasion will afford an opportunity for us to enjoy an outing together.

MEMBERSHIP COMMITTEE

The membership committee has organized in three sections, and a few new names have been added to the committee roster since the September JOURNAL was issued. We therefore give below the complete personnel of this committee:

E. S. CARMAN, *Chairman*

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EMPLOYMENT BULLETIN

This department is for the use of members desiring positions or requiring engineering services; it is under the personal direction of the secretary, who is anxious to increase its value to the members. Therefore, if you are in need of engineering help, or desire to secure a position, do not hesitate to call on the department for assistance.

All information is handled confidentially.

MEN AVAILABLE

No. 8A. American; 33 years of age; graduate Columbia School of Mines, mining engineer; Case School, three years; eight years' experience in mining work as draftsman, surveyor, engineer and superintendent. Desires position as mine superintendent or mining engineer.

No. 9A. American; 24 years of age; two years in civil engineering at Purdue University. One and one-half years' general shop experience, and two and one-half years as draftsman in land department of railroad office; one year as municipal assistant engineer. Desires selling work, preferably in machinery line.

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CONTENTS

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Smoke Prevention

By Paul P. Bird.

Editor's Note.—When the author presented this paper, he showed, by means of lantern slides, a large number of boiler settings that have operated successfully without smoke. A few of these drawings are reproduced here, without special reference being made to them in the text.

You have asked me to address you on a subject that is, in my opinion, of far reaching and increasing importance to all communities where soft coal is used. In approaching this subject, I desire to call your attention to the fact that the prevention of smoke is an engineering problem and worthy of your most careful thought and study. Broadly, the engineering profession is responsible for the smoke nuisance because the general use of coal as a fuel has brought with it the smoke, and the development of coal burning apparatus has been essentially the work of the engineer. As it is the work of the engineer that has brought into being the smoke nuisance, it follows that it is the duty of the engineer to give study to this problem and to put into practice means for its abatement. The engineering profession is not an old one. It is only within the last 60 years that coal has come into general use for producing heat and power. During this period, which has been called "the epoch of manufactured power", wonderful achievements have been made, and the accomplishments of the engineer have worked a revolution in human life and brought about one of the most remarkable eras in the annals of civilization. Now, if the wheels of industry must necessarily stop, and if we must abandon the present methods of making heat and power if the smoke stops, then there is no question but that the making of smoke must continue. However, if it is possible to burn this coal and to produce this power and heat without smoke at all, or with the production of less smoke than we are now making, it should be done. The individual or corporation who burns coal should see to it, as a civic duty, that this is done, and unquestionably city governments have a perfect right to insist that every effort be made toward this end.

It is now a generally accepted fact that smoke cannot be abated by requiring, by law, the use of smokeless fuels such as anthracite coal or natural gas. Soft coal must be used, but every effort must be made to so burn it that the minimum of smoke is made.

Considerable attention has been paid to this subject in Chicago during the last few years, and with success. Mr. T. E. Donnelley, chairman of the Chicago Smoke Abatement Commission, spoke before your Chamber of Commerce a few months ago about the work of his commission and the work of the Department of Smoke Inspection. This paper, therefore, will not

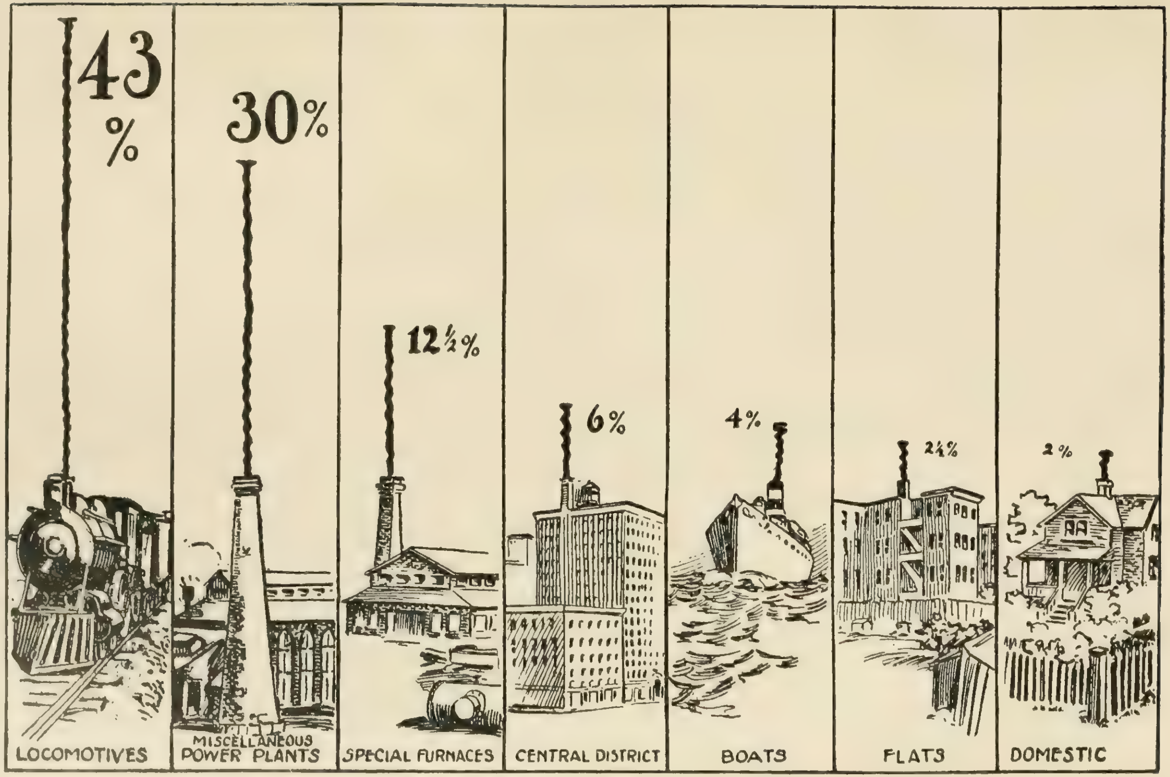
deal with the subject of smoke ordinances and their enforcement, but rather with the practical and engineering features.

In dealing with any problem it is usually of benefit to make as careful an analysis as is practicable of the things and conditions involved. Therefore, in studying the smoke problem of a city, it is desirable to examine the way in which the soft coal is burned and to make a subdivision of total smoke amongst the various classes of plants responsible for its production. The Chicago Smoke Department during the past year made such an investigation and the results obtained have been of the greatest value to those who are directing the fight against the smoke nuisance. As far as is known, no similar study has ever been made, and therefore the work was done along original lines. As the smoke comes from the incomplete combustion of soft coal, the basis of such an investigation is the soft coal consumption of the city. Knowing the coal consumption of the different classes of smoke makers, it requires a knowledge of the density of smoke made by each class to arrive at the percentage of the total smoke made by each. For this purpose the Chicago Department used the Ringlemann method of estimating the relative blackness or density of smoke. The smoke makers were divided into seven groups or classes, their coal consumption carefully estimated, and many thousand Ringlemann chart observations made of the smoke. The results of the investigation were:

		Annual Coal Consumption.		Smoke.		
					Percentage of Total Smoke.	
Class.	Consumer.	Tons.	Per cent.	Percentage of Density.	As Figured.	Round Numbers.
1	Central district	1,500,000	15.	3.75	5.85	6
2	Misc. power plants	4,500,000	45.	6.5	30.45	30
3	Flats	750,000	7.5	3.0	2.34	2½
4	Domestic	650,000	6.5	3.0	2.06	2
5	Special furnace	600,000	6.	20.0	12.5	12½
6	Railroads	1,850,000	18.5	22.3	42.9	43
7	Boats	150,000	1.5	25.0	3.9	4
	Total	10,000,000	100.0	9.6	100.0	100.0

In making use of the Ringlemann chart, the results were figured on a percentage basis. The third column in the table gives the percentage of smoke density. The results are illustrated in a graphical way by the drawing on page 73.

The Chicago investigation showed that although the railroad locomotives used only 18½ per cent of the total coal, they made 43 per cent of the total smoke. The average density of locomotive smoke was 23 per cent, while the density of smoke from the miscellaneous power plants averaged only 6½ per cent, and all the plants in the central district averaged as low as 3¾ per cent. The miscellaneous power plants were second as far as quantity of smoke is concerned, being responsible for 30 per cent of the total. One of the surprising results of the investigation was that the domestic users of soft coal, *i. e.*, private residences,



PROPORTION OF TOTAL SMOKE OF CHICAGO, MADE BY DIFFERENT CLASSES.

cottages, two and three-flat buildings, etc., were responsible for but 2 per cent of the total smoke.

The possibilities of preventing smoke from these various sources will be next discussed:

STATIONARY PLANTS:—

Although in the Chicago investigation the smoke makers were divided into seven classes, the sources of smoke in any city may be roughly grouped into three broad divisions—stationary plants, railroads and boats. Smoke from the stationary plants forms the most important part of any Smoke Department's work and in most cities it forms considerably more than half of the total. In this group are found all boiler plants (whether used for power or heat production), special furnaces in manufacturing premises, and the heating plants in homes. A great deal can be done to prevent smoke in stationary plants, and it is here that the greatest successes have been accomplished.

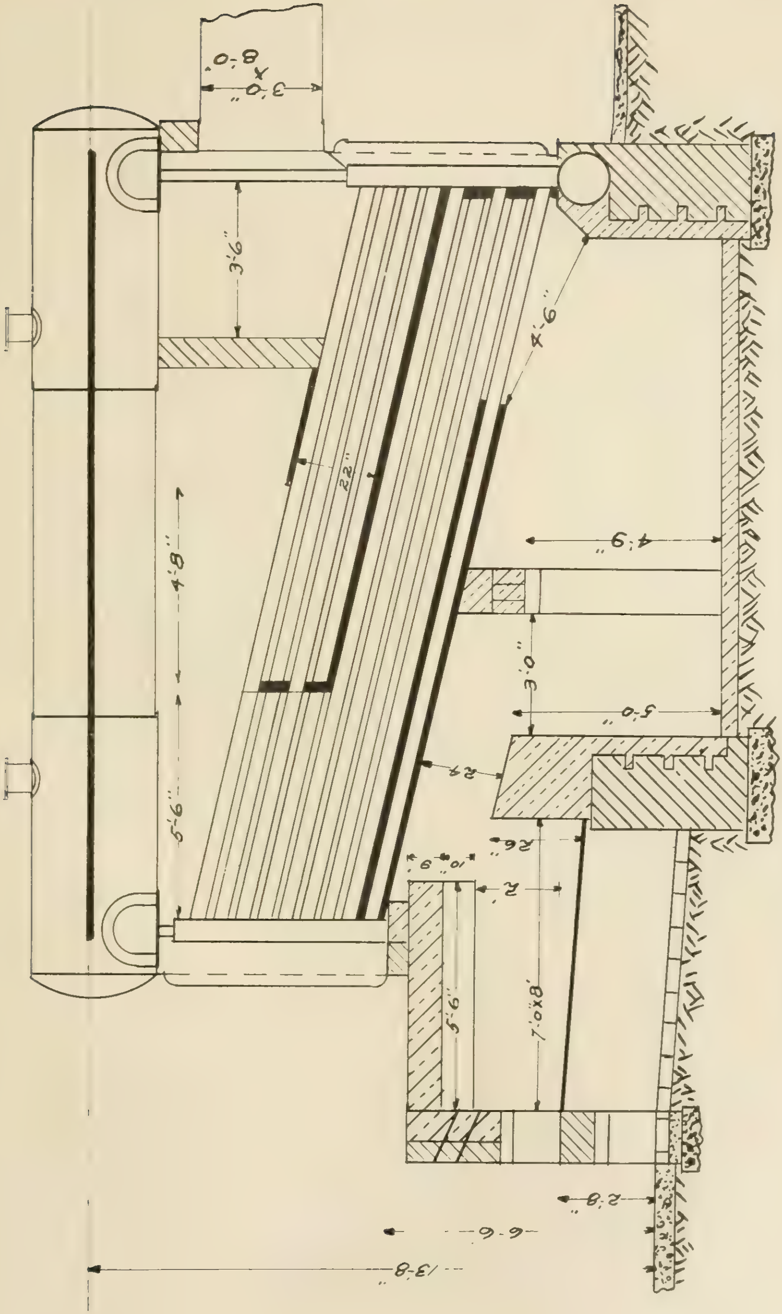
Referring to smoke prevention in boiler plants, it may be noted that there are three things which determine to what extent a boiler plant will smoke:

1. The kind of fuel to be used.
2. The care to be exercised by the fireman.
3. The character of the equipment for burning the fuel.

A city smoke department has no control over the first of these. The kind of fuel is fixed by geographical location and commercial considerations. In the west soft coal must be used.

A city department can influence to some extent the care to be exercised by the fireman. When a plant through careless firing throws out objectionable smoke in violation of the law, the city can impose a fine upon the plant owner, and in this way exert an indirect influence on the fireman. So much has been said about careless firing that the public often loses sight of the fact that there are other features to be considered and wrongfully attributes all smoke to carelessness. In a great many of the plants today it is probable that more care is required on the part of the fireman in order to prevent smoke than can reasonably be expected from men of this class. These plants are often located in dark, poorly ventilated basements, hot almost beyond human endurance, only a very limited amount of space provided for operating the furnaces, and the general appearance and arrangement of the plant such that it can hardly be associated with care of any degree. In these plants to merely keep up the steam pressure is such a task that no extra work is apt to be done for the sole purpose of preventing smoke.

The third feature, the equipment, is the only one over which the city has any direct control. If smokelessness is to be brought about the general standard of the equipment must be such as will make up for the natural conditions of fuel and allow for at least pardonable carelessness. Past experience has proven that unless detailed attention is paid to the equipment, plants will be installed in which bituminous coal cannot be burned without smoke, even when extreme care is used. Such poor installations are not made

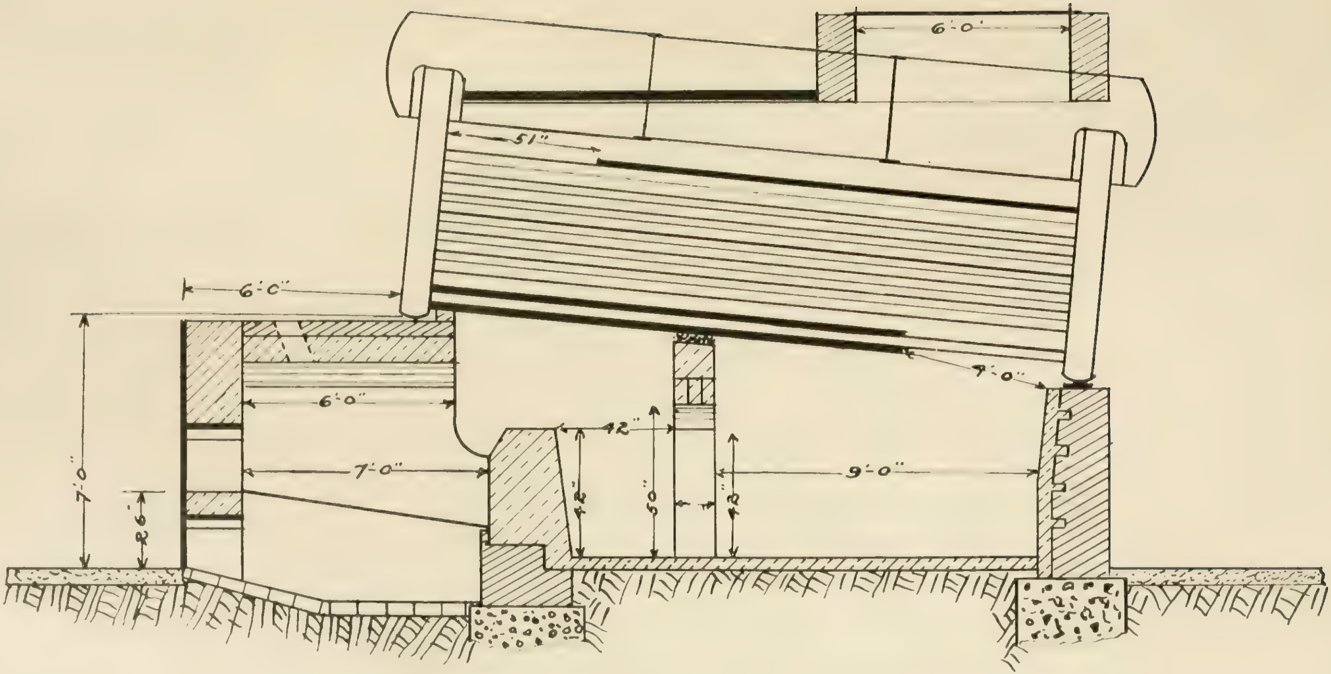


Water Tube Boiler Horizontally Baffled and Arranged for Hand Firing—Note Deflection Arch Behind Bridge Wall.

willfully by anyone who wants to make smoke and violate the city ordinances, but the mistakes are made through ignorance and because boilers and furnaces are installed without regard to the particular conditions that exist. A boiler plant that would operate very satisfactorily in the eastern states with anthracite or the better grades of bituminous coal will smoke very badly when using western coal. Further, it is only within recent years that engineers have given careful study to the details of boiler plants, with the idea of smoke prevention. When boilers and furnaces are installed according to well-established standards, which for the most part have been developed in the east, the result is most unsatisfactory from a smoke prevention standpoint. In Cleveland, where every conceivable industry is carried on and where the most diversified classes of smoke making plants have been permitted to grow with no thought or provision made for avoiding smoke, its suppression is a task requiring time, patience, firmness and a fund of knowledge and experience capable of solving the various problems submitted.

The 1907 smoke ordinance of the City of Chicago provides that permits be issued by the Department of Smoke Inspection for all new steam plants and for the re-construction of old ones. This was the first time in the history of municipal smoke prevention work that such a program was undertaken. Those who planned this section of the ordinance felt that if any permanent and lasting good were to be obtained, the details of every steam plant equipment should be carefully studied before construction, and every precaution taken to so build them that smoke may be prevented. It is a pleasure to be able to state nearly four years after the ordinance was drawn and put into effect that the important work of city supervision of new plants has been successful and that it is now considered a very important, perhaps the most important part of the work. This city supervision commences with the building plans and the smoke inspector approves the plans of any building in which a boiler plant is to be located before work on the building begins. This is very essential, as it is only by this means that enough space can be obtained for the boiler room and sufficient space is the first requirement for a good boiler setting. Before the boilers are installed, the smoke inspector issues a permit covering everything that affects the smoke-making characteristics of the plant. The points usually covered are: Chimney height and area; breeching design; damper; areas of gas passages; design of furnaces; stokers; capacity of boilers, etc etc.

The Chicago Smoke Department has gone into the matter of supervision of new plants very thoroughly, and it goes so far as to specify the heights above the floor at which boilers of various types must be set, where No. 1 fire brick must be used, where No. 2 brick may be used, the height and diameter of stacks, the shape and area of breeching connections, the areas of gas passages through the setting, the arrangement of baffles, etc. The department gives the most careful study to every plant submitted and holds every one up to the same standard. The result of about three and a half years' of this work has been to bring



A Heine Type Boiler with "Dutch Oven" Furnace for Burning Wood Refuse

Chicago into the front rank of the world's cities which are fighting the smoke nuisance. You cannot find an intelligent and honest man in Chicago who does not believe it pays. It has taken a lot of fighting to make men spend more money in building boiler plants than they expected to just for the purpose of preventing smoke. Similarly it has been hard to convince them that they must rebuild their plants, add new boilers, equip their plants with stokers or build new stacks, all to stop smoke. A smoke inspector must have the backing of a strong public opinion in order to carry through such a program, but this must be done if smoke is to be stopped. There is no easy way to do it. It is an engineering problem and each job is different and requires close detailed study. It takes time to bring results in a campaign of this sort. The results come slowly but surely and there can be no doubt but that this is the only way to get permanent and lasting results.

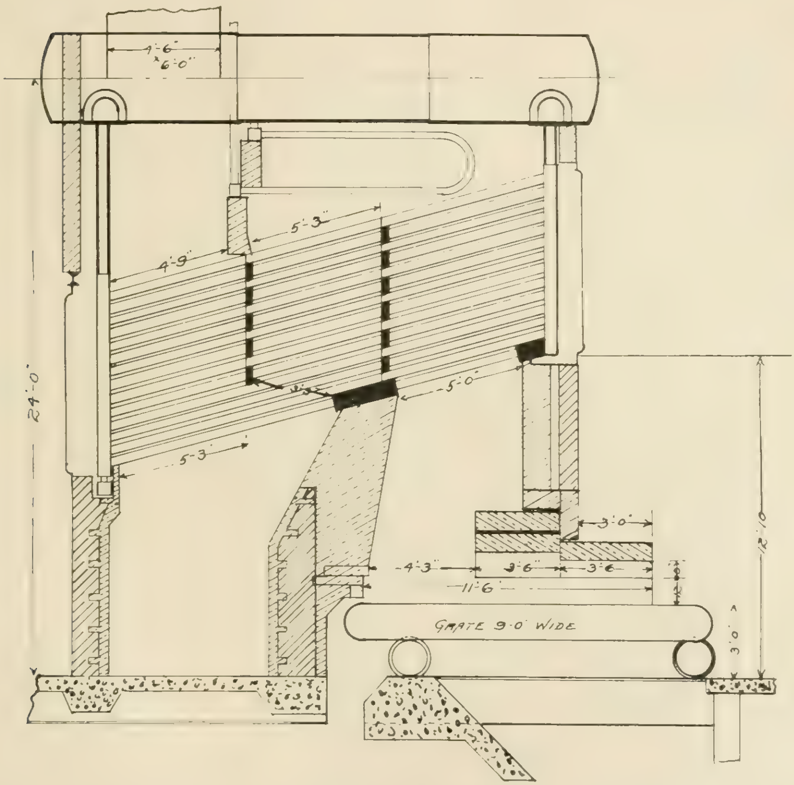
The most important thing to look after in the design of a boiler plant is draft. It stands as the first and most essential requisite for smokeless operation. Provision for meeting the other requirements of smokelessness cannot take the place of adequate draft. In general, a chimney should never be built lower than 100 feet above the grate level. This represents the lower limit of stack heights.

The only function of a breeching is to convey the products of combustion from the boiler to the stack. In designing the breeching, care must be taken to avoid its interfering with the function of the chimney, which is to get intensity of draft over the fire. Available draft at the base of the chimney is procured by its height and the money invested in chimneys increases enormously with the height. Therefore, any design of breeching which uselessly uses up the available stack draft is a source of constant loss to the owner, inasmuch as he has money invested in a chimney that is not giving him full return, to say nothing of the annoyance caused by the barrier in the way of smokelessness. Therefore, as much attention must be given to the design of breeching as to the design of chimney.

The Chicago department often asks for extensive changes to be made in the general layout of a plant in order to avoid one right angle turn in the breeching. Sudden changes of cross section must be avoided and the section maintained as nearly square or round as is possible. If the section of the breeching must be changed in order for it to enter the stack, the breeching must be so arranged that the smoke will go up and not down as it enters. Bends of long radius are substituted for short turns when possible. The design must be such that opposing currents of gases will be avoided.

The value of automatic stokers as smoke preventing devices is universally recognized, and it is only in the smaller plants where conditions are unsuitable for stokers that hand fired boilers should be permitted. In all plants having a boiler capacity of above, say, 300 horsepower stokers should be required unless there is some good engineering reason why they should not be

installed. The important thing relative to stokers is to install them properly. Much could be said on this point. A good boiler and a good stoker may be chosen and yet they may be put together in such a way that the result will be most unsatisfactory from a smoke prevention standpoint. The stoker must be so arranged with reference to the boiler that the combustion of the fuel is complete before the gases come in contact with the boiler itself. There are many stoker fired plants that are not successful in preventing smoke. The fault is not due to the particular



WATER TUBE BOILER, VERTICALLY BAFFLED AND EQUIPPED WITH CHAIN GRATE STOKER—NOTE EXTREME HEIGHT OF SETTING.

boiler or the particular stoker, but to the manner in which the two have been installed in relation to each other. In general, high settings are necessary and large combustion spaces. The area of the gas passages through the setting and furnaces must be of sufficient size to allow a good draft over the fire.

Regarding the subject of economy, there is probably no one today who will deny it is economical to prevent smoke. Mechanical stokers are coming into universal use not only in cities, but everywhere, whether smoke is a factor or not, and the general

adoption of stokers brings with it smoke prevention and economy. Although, in general, there is great economy in stopping smoke, it is not on this ground alone that an anti-smoke campaign should be carried on. Complete combustion means economy and also no smoke. Probably the carbon particles in visible smoke represent a very small part of the heat value of the coal, but it is found that in practically every case, where a plant is changed from being a smoky one to a clean one, the economy is improved. An engineer who is careful about his smoke is also careful about the other parts of his plant. A fireman who fires so as to prevent smoke also fires in the way that gets the most heat from the coal. It is the universal experience of every one who has worked in this line that it pays to stop smoke. By this it is not meant that there is so much actual heat value in the carbon particles that escape in smoke, but that smoke is caused by faulty design in some part of the boiler plant or poor operation. When the poor design is corrected—stack or breeching improved so as to get proper draft, grate surface properly proportioned to the boiler and load, baffles arranged correctly, etc., or when the operation is improved, it is found that not only does the smoke disappear, but the economy improves—the plant efficiency goes up, often cheaper coal can be used, and sometimes the capacity of the boiler plant is materially increased.

When a boiler stack emits absolutely no smoke at all, it does not follow that the economy is high. It may be that there is a great excess of air in the chimney gas with a correspondingly low efficiency. The supply of air to a furnace, particularly with hand fired boilers, is often overdone and although the smoke is prevented, fuel is wasted and a low boiler efficiency needlessly obtained.

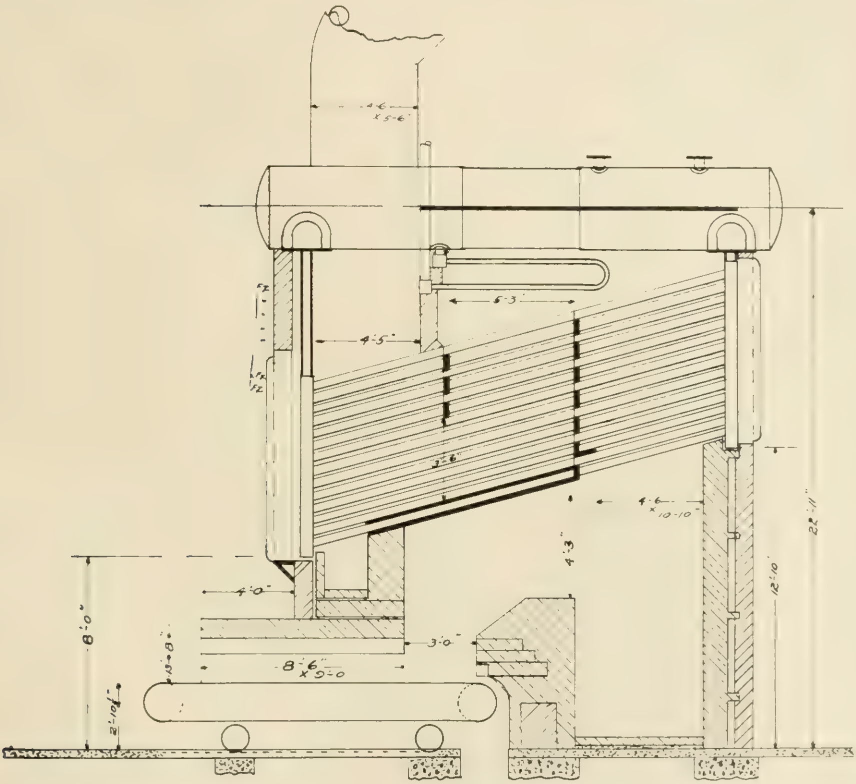
On the other hand, some smoke being emitted from a boiler stack is not always a sign of poor economy. This condition is usually the result of a peculiar design of furnace. It may happen that the plant is so designed that it is running economically, but without complete smoke prevention. In such a case the complete elimination of smoke does not decrease the efficiency, but it may not improve it. In boiler plants subject to extremely variable loads, it is very difficult and almost impossible to prevent smoke at all times. In such plants the economy is rarely improved by changing the design or operation for the purpose of eliminating smoke.

It may well be asked why is it necessary for the anti-smoke crusader to bring all of this to the attention of power plant designers and operators? Why are not our plants today correctly designed and operated? Probably the answer is found in the fact that today there is less known about boilers, boiler settings, breechings, stacks, furnaces, stokers, furnace economy, boiler efficiency, etc., than about any other part of a modern power plant. Because of this lack of knowledge many plants are improperly designed and built. But engineers are paying more attention to the boiler room, realizing that it is the part of the

power plant that needs the most attention and offers most opportunity for reforms and improvements.

RAILROADS:—

As outlined above, it is estimated that in Chicago the railroad locomotives make 43 per cent of the total smoke. Considering its character, the conclusion seems warranted that steam locomotives produce over one-half of the dirt traceable to smoke. Locomotive smoke carries with it quantities of sparks and cinders,



B. & W. TYPE BOILER WITH CHAIN GRATE STOKER SET UNDER REAR END, ALLOWING A "TILE ROOF" FURNACE, BUT RETAINING THE VERTICAL BAFFLES

while in stationary plants comparatively little of such material is thrown out. This is because of inherent features in the design that are unavoidable. On a locomotive there is so little room available that the grate surface of the boiler is necessarily small and there is consequently required a powerful draft for burning enough coal to do the required work. This draft is obtained by discharging the exhaust steam from the engine cylinders up the stack. Because of this strong draft, there is drawn out of the fire box with the smoke great quantities of fine coal and ash.

which in turn are discharged from the stack in the form of cinders. It is a recognized fact among railway men that from 8 to 18 per cent of all bituminous coal put into locomotive fire boxes escapes from the stack in this manner. In Chicago about 5,600 tons of coal are burned in locomotives each day. Assuming that 10 per cent of the coal leaves the stack in the form of cinders, it means that 560 tons of cinders are thrown into the air and dropped on the city of Chicago every day. This is equal to about 14 carloads. On the other hand, in stationary plants, where there is plenty of room for a larger grate surface and where the coal is burned with a lower draft and with tall chimneys, but few cinders are carried out with the smoke. Therefore, the smoke from locomotives on account of carrying with it sparks and cinders is far more objectionable than the smoke from stationary plants, and as it is discharged into the atmosphere at no great distance from the ground and is trailed over long courses, it is safe to say that from the standpoint of a nuisance the steam locomotive is the worst offender of all.

Considering the remedy for this class of smoke, it may be said that as long as the steam locomotive burning soft coal is used, smoke will be made. The investigations recently made in Chicago showed that the average density of locomotive smoke, according to the Ringlemann system, was 23 per cent. This was the average figure obtained within the city limits. Similar investigations made in eight towns outside of the city limits showed an average smoke density of 41 per cent. This is probably a fair figure for the performance of a locomotive using Illinois or Indiana coal with no particular attention paid to preventing smoke. It shows that outside of the city, where no effort is made to prevent it, the smoke is nearly twice as dense as in Chicago. The lowest average smoke density made by the locomotives of any railroad was 10.7 per cent. Probably 10 per cent is as low an average as can be maintained with steam locomotives using soft coal. If all the locomotives of Chicago were doing as well as this today, the locomotive smoke would still be 29 per cent of the total, and probably be responsible for more than one-third of the dirt. The modern steam locomotive is such a highly developed machine that it is extremely unlikely that any change will ever be made in its construction which will produce better results than this. Although there are several devices which may be applied to a locomotive which are helpful in preventing smoke, a careful and skillful fireman is the greatest factor. A careful man with a locomotive having no special devices of any sort and burning very poor coal will make far less smoke than a careless man with the best devices and coal. The railroads in Chicago that are making the least smoke are those that are paying most attention to the men on the engines. These roads employ smoke inspectors, road foremen or instructors who work with the engineers and firemen, showing them how to fire carefully, how to use the devices and how to operate their locomotives under all conditions with the minimum amount of smoke. There can be no let up in this work. Experience has shown that when this

personal supervision of the men is stopped a period of even two weeks, the men are back in the old habit again.

The best equipment that a locomotive may have for the purpose of preventing smoke consists of:

FIRST:—A strong and efficient steam blower in the smoke stack. This blower pipe should have at least 1¼-inch steam connection and should be so equipped with valves that either the engineer or fireman may use it. This is for the purpose of supplying draft when the locomotive is not running. This blower should always be used when the engine stops and the fire is in such condition that smoke will be made unless there is a strong draft. The best blowers have special tips or nozzles which discharge the steam through several openings.

SECOND:—A brick arch in the fire box. This arch is for the purpose of giving a high temperature to the fire box and causing the gases to mix well with the air while in that part of the fire box where the temperature is high enough for combustion.

THIRD:—The fire boxes may be equipped with combustion tubes. These consist of tubes, about 2 inches in diameter, extending through the water space on each side of the fire box which admit air above the level of the fuel bed. Depending upon the size of the fire box, from four to six tubes of this sort are to be placed on each side. A current of air through these tubes is insured by blowing a small jet of steam through them by means of a pipe, about ⅛ inch in diameter. These combustion tubes have come into very general use in the Chicago district.

Several different forms of automatic stokers have been developed for use on locomotives. Practically none of them have been of any assistance in preventing smoke, and most of them have caused more smoke than hand firing. The Pennsylvania railroad, however, is now developing a stoker which gives promise of reducing smoke to a minimum, but which is not yet at a point where it is available for general application by the railroads.

Summing up the railroad smoke problem, the author's conclusions are that as long as steam locomotives, burning soft coal, are used, considerable smoke will be made, and that when this is reduced to the minimum the smoke from this source will still form a very considerable part of the smoke produced in any city. Further, electrification of the railways seems to offer the only final and satisfactory solution of the problem. An investigation is now being made of electrification in Chicago by the Chicago Association of Commerce Committee on Investigation on Smoke Abatement and Electrification of Railway Terminals. The railroads operating in the city are paying for the work. Mr. Horace G. Burt is chief engineer and he has associated with him a staff of experts who are giving careful consideration to everything bearing on the subject of railway smoke. Although this Committee and its staff of engineers are not working directly for the city of Chicago, it is expected that the findings of the Committee will be accepted by the public, the city council and the railroads as to whether or not electrification is necessary and possible.

The task undertaken involves a vast amount of time and labor. The report will probably be finished within the next year or year and a half.

Boats:—

As a general proposition, it may be stated that it is just as easy to prevent smoke on a steamboat as it is on a railroad locomotive. When the Chicago Smoke Department commenced its work in the fall of 1907, every operator of vessels on the river told the Department that the anti-smoke fight was all right on land, but that a steamboat or a steam tug had to make smoke in order to run. After three seasons' work on the river, the Department came to the conclusion that it is no harder to operate a vessel on the river without making smoke than it is to operate a locomotive without smoke.

All marine boilers and machinery are inspected and licensed by the Federal Government. Therefore, a city department cannot issue permits for the installation of marine boilers or for reconstruction and cannot control the equipment in any way. Even if this were not the case, it would be difficult to make much improvement in the machinery of steamboats for the purpose of preventing smoke. There are no devices which can be attached to marine boilers which are of any great assistance in stopping smoke. About all that can be done is to make sure that the boiler capacity is large enough to operate the vessel without overloading the boilers and that the grate surface is of sufficient size for the coal to be properly burned. Automatic stokers have not come into general use on steamboats; first, because of the limited space available in the boiler room for this sort of machinery, and, second, because a regular supply of coal of uniform size is impossible to obtain. There is only one form of stoker that has worked out at all in connection with marine work and that is the underfeed stoker. In Chicago there are one suction dredge, one tug, and one passenger boat, already equipped with stokers of this sort. These stokers have thus far worked out excellently from a smoke prevention standpoint, and it is hoped that many more of them may be installed.

In Chicago the use of Pocahontas coal has done more than anything else toward stopping smoke on boats. Formerly all vessels used Pittsburgh coal, which is quite common at all points on the Great Lakes. This coal is very smoky, as you in Cleveland know. Today practically every boat uses Pocahontas coal while in the Chicago river and harbor. The tugs are using it, and the freight and passenger boats while in the city. It took a lot of hard work and three years' time to bring this about, but it has resulted in reducing the smoke to a remarkable extent. It is probably fair to say that a greater proportion of smoke has been abated among the boats than among any other single class of smoke makers in Chicago. A few years ago the smoke from the boats on the river was a bad nuisance, while today, although there is still considerable smoke, the improvement has been

marked. This has chiefly been brought about by the use of Pocahontas coal and more careful firing. You may be assured that smoke prevention, even on a tug boat, is by no means a hopeless task.

Discussion

W. M. Faber:—

I suppose what you want to know is what the company which I represent has been doing in the way of correcting the smoke nuisance, and how we are planning to conform to the new smoke ordinance that we understand is to be made a city law in the near future.

At the Consolidated Works of the American Steel & Wire Co., some few years ago, we were confronted with the necessity of reconstructing our boiler house, and among other things seriously considered was the cutting down of smoke to the minimum, at the same time maintaining good economy in our operation of the boiler house.

At this plant we had two boiler houses, with a total of some 30 boilers with individual stacks, and you can rest assured that very little attention was paid to the large amount of smoke that was necessarily produced. In our contemplated plans for reconstructing we centralized our boiler house, and made the equipment so that two large stacks would take the place of the 30 small stacks.

After the boilers and stokers had been contracted for, we had a meeting of the engineers of the boiler and stoker companies, with our own engineers, to consider the most satisfactory way of installing these boilers so that we would get practically a smokeless combustion of the fuel, and at the same time get the best of economy in our daily operation.

The result of this conference is the boiler house, now supplying steam for the Consolidated Works, and the furnace construction is such that it has practically obliterated the smoke nuisance at this plant. The construction of the furnace is as follows: Stirling boilers were adopted and plans were made for setting them higher than the ordinary setting; flat ignition arches were built, extending approximately 48 inches over the front of the stoker, with an additional Stirling arch, extending from the end of the flat arch forward over the balance of the stoker. This arrangement gave a large combustion chamber roofed over with arches, as explained.

The draft conditions in this boiler house are approximately 1½ inches at the stack, giving a draft in our furnace of approximately 0.3 to 0.5 inch. We are able to run these boilers, due to the draft conditions and grate areas, at 140 per cent of their rating, but do not ordinarily run them at a rating greater than

120 to 125 per cent. During their operation, they are practically smokeless, except when dampers are closed—these dampers being controlled by damper regulators, which operate when the steam pressure goes beyond a given point.

Mr. Bird, in his paper, gave as examples of boiler settings that gave good results, water tube boilers, set some 5 to 6 feet above the stokers. To change our boilers to conform to these ideas would be practically impossible, but we can, and expect to lengthen out our stoker ignition arches, and are making efforts in this direction on all new work that we are putting in.

Our boiler houses are not giving us as much concern in regard to the elimination of smoke as our smaller furnaces, such as annealing, galvanizing and other various heating furnaces, and we are, at the present time, trying various temporary expediences to cut down the smoke in these smaller furnaces. If our small furnaces were so located that a gas producer could be connected to them, we might possibly solve the trouble in this way, but as a matter of fact, they are scattered throughout our plants and are of such small size individually, that in some cases only from 50 to 75 pounds of coal are burned per hour.

The operating managers of our company are not only expecting to conform to the requirements of the new smoke ordinance, but are making every effort at this time to anticipate these requirements, and have sent out instructions to our various mill superintendents, to get their furnaces in such condition that they will not make obnoxious smoke. This already has resulted in improvement at several of our plants, and we anticipate that, because of this vigorous action on the part of the men in direct authority, a continued improvement will be made throughout our plants in this city.

In conclusion, we might add that while the managers of our company are making these efforts toward abating the smoke nuisance, they view with surprise the number of stacks located throughout the central part of the city that are allowed to make smoke without any apparent action being taken by the city smoke inspector. Two stacks that have been particularly noted are, one at the Hollenden hotel, and one on the Plain Dealer building.

A. G. Trumbull:—

The silence which is being maintained by my fellow railroad men here, this evening, appears to call for some remarks from me, else it may be thought that the railroads are particularly guilty of smoke emission in Cleveland.

It is trusted that the figures that have been quoted by Mr. Bird as representing the relative percentage of emission of smoke by the railroads in the city of Chicago, as compared with industrial establishments, and the other chief smoke producers, will not be regarded as representative of the conditions in Cleveland. The Chicago territory being under my jurisdiction, a favorable oppor-

tunity is afforded for comparison, and it is my opinion that the smoke from locomotives in Cleveland is far less in volume than in Chicago.

It may be of interest to the Society to learn something of what has been done by the railroads in connection with the smoke problem. Some time ago, a committee representing each of the roads entering the city was formed to study the problem and adopt such measures as were considered likely to yield the best results. Through the influence of this committee, practically all of the locomotives entering the city have been equipped with the appliances for smoke abatement mentioned by Mr. Bird, including smoke box blowers, combustion tubes and steam jets, while a large number have also been equipped with the brick arch, the use of which is being extended.

As engineers, we may perhaps admit that the absolute elimination of smoke from locomotives burning bituminous coal cannot be attained, but we do claim that objectionable black smoke can be prevented, and you can satisfy yourselves of the correctness of this statement any day by personal observation.

Those of us who reside in Cleveland, and especially all who may live comparatively near the center of the city, have at least some conception of the damage which smoke is causing and, appreciating the necessity for an abatement of the smoke nuisance, may be depended upon to extend our efforts and render every possible assistance in accomplishing the desired result.

JOSEPH HARRINGTON:—

The paper presented by Mr. Bird is so complete and touches upon so many of the vital points of smoke prevention that any discussion thereof must necessarily be merely an elaboration of some of the statements made by Mr. Bird.

Vital facts are stated by Mr. Bird in a single sentence, and I desire to select one of these for further emphasis, inasmuch as it appears to me one of the most important and one of the least appreciated in the entire discussion of smoke prevention. This is the statement that a well designed stoker and a well designed boiler may be improperly joined so that bad smoke will result and that the union of these two elements must be correct in order to secure the desired result.

It is so often thought that smokelessness depends upon a proper selection of boiler and stoker, and it is so often claimed that such is the case, that the layman does not fully appreciate the necessity for an adequate furnace which is the bond of union between these two parts. The stoker, after all, merely provides means for uniformly and gradually introducing the fuel to the furnace and removing the refuse therefrom, and the boiler is merely the means provided for absorbing the heat developed by the combustion of the fuel. The furnace, however, is the necessary space required for the combustion of the fuel and of the

resultant gases, and it is this very thing which more than any other contributes to the appearance of the stack.

Every furnace has a certain capacity, and if furnace capacity were properly understood and could be proportioned to suit the peculiarities of the stoker, complete smokelessness would necessarily result in each case. A certain combination of stoker and furnace may be smokeless, up to a certain rate of combustion, and very smoky when this rate is exceeded. This simply means that the capacity of the furnace to hold the gases during combustion at the proper temperature and for the proper length of time has been exhausted. Certain stokers provide a better introduction of the fuel, permitting the furnace to be reduced to practical proportions and in this way the stoker influences the smokelessness of combustion. The tendency, however, is to reduce the furnace to its absolute minimum, and the great fight of the smoke inspector is to induce the consumer to supply sufficient room for the building of adequate furnace space. So many owners of plants being forced into a rehabilitation thereof by the insistance of the smoke inspector, begrudge every inch of space taken up by the furnace, and will invariably protest and squirm when furnace projection or boiler height is desired. Furnace projection permitting construction of a furnace of adequate length requires possible encroachment upon coal storage space or the enlargement of the entire building. The height of boiler which is required in certain types for the proper proportioning of the furnace requires higher head room under bunkers or floors.

However apparent and commonplace the above assertions may appear to the well posted engineer, it remains a fact that the layman who has the obligation placed upon him of cleaning up his stack will fight every inch of space required for the furnace. It is my sole desire in the repetition of these truths to bring out more emphatically the absolute necessity of adequate furnace in the production of smokeless combustion, and to add my voice to the testimony of those who have similarly argued in the hope that some person may be influenced thereby, to see the absolute necessity of adequate furnace and allow his engineer or the smoke inspector to take such steps in his boiler room as he well knows are absolutely required.

E. H. Whitlock:—

Perhaps the fact ought to be emphasized that the boiler itself and its capacity for generating steam is independent of the fire box and setting. In other words, the amount of steam generated depends on the number of heat units delivered to the boiler.

I think, perhaps, a few remarks made by Mr. Bird at luncheon might be emphasized, namely, that in many cases the damper openings are of insufficient area, also the areas at various points where the baffles are inserted are frequently reduced so as to be of insufficient size. These features have a great bearing

on the production or non-production of smoke in the boiler setting.

The stack and stack area is another independent feature which tends for or against proper combustion of fuel. I think Mr. Bird remarked that in many cases attention to these points would tend greatly to mitigate the smoke nuisance in boiler settings that are now in use.

W. Beahan:—

It is disappointing to learn by this paper tonight that 43 per cent of the smoke in Chicago is made by the railroads. I feel sure that percentage is not so high in Cleveland. And I am very glad to hear from Mr. Trumbull, of the Erie, of the good efforts his road is making, and to listen to his clear and well-put statement. As I am not of the Motive Power Department of the Lake Shore Road, I cannot say authoritatively what our company are doing, but I know we are giving the matter our attention. The modesty of our men here tonight is commendable but regretted.

I am much pleased to have Mr. Bird tell us that the *man* who does the firing is an element to be reckoned with. Is not the *man* always to be counted in these matters? The idea which some of our signal men have that appliances can be made so that *any* man will serve is a fallacy. Railroads must have good men. They must be constantly getting good young men. In large enterprises no service is more important than its recruiting service.

Study and experiment will do much to lessen the smoke evil. We all agree to that. Panaceas must be shunned. Let us go slowly and thereby go surely.

But I cannot agree to the proposition that, in general, electrification is now practicable on railroads through cities as a means of smoke prevention. The time has not yet come. We must not invest money in transportation methods not yet beyond the laboratory stage. We have done too much of that. We read that such an installation in New York City has paid but 1½ per cent on the investment. It is futile to propose, as engineers, what financiers cannot go into the money market and secure funds to carry out. You cannot divorce engineering and finance in transportation matters today.

Rules for Firing in Force in Chicago

Editor's Note:—These rules were prepared by Messrs. Moynette and Oyster for use in Chicago Harbor.

COMING INTO PORT

Clean fires before reaching Chicago.

Before entering the harbor, shove fuel to rear of grates, clearing about 2 feet of front grate surface; cover burning fuel with about 4 inches

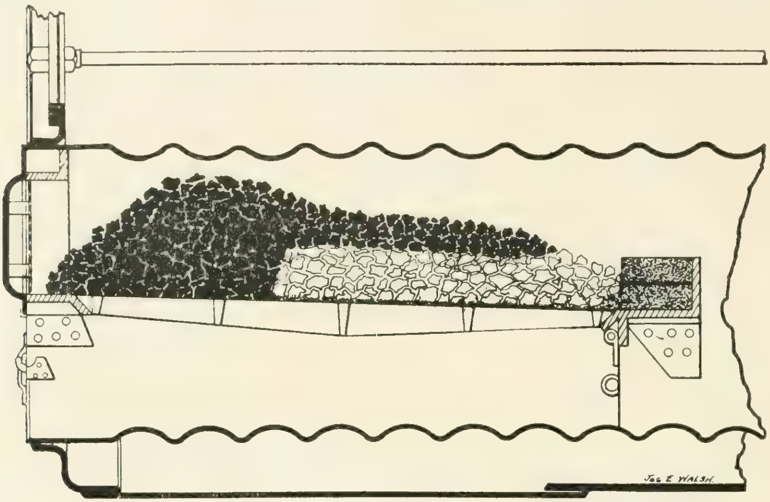


Fig. 1—Fire in Condition to Enter Chicago Harbor.

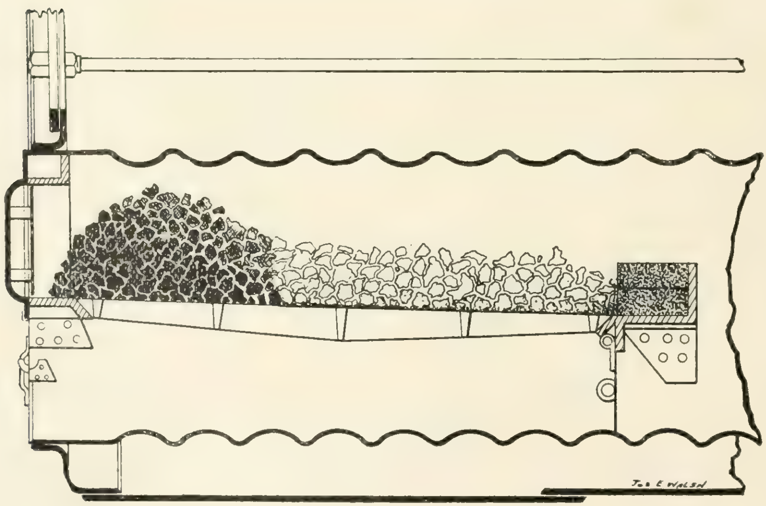


Fig. 2—Fire Ready to Push Back.

of fresh coal and fill cleared space with broken coal almost to top of furnace; leave door cracked for short interval and put on blower. Have all fires in the condition shown in Fig. 1, when abreast the Life Saving

Station. The vessel will then be able to reach her dock without again working the fires.

All further firing while in the Chicago river should be with Pocahontas coal.

FIRING AT THE DOCK

When steam is required, or fire on rear of grate gets low, push coked coal back and quickly charge front of furnace with fresh coal, as before.

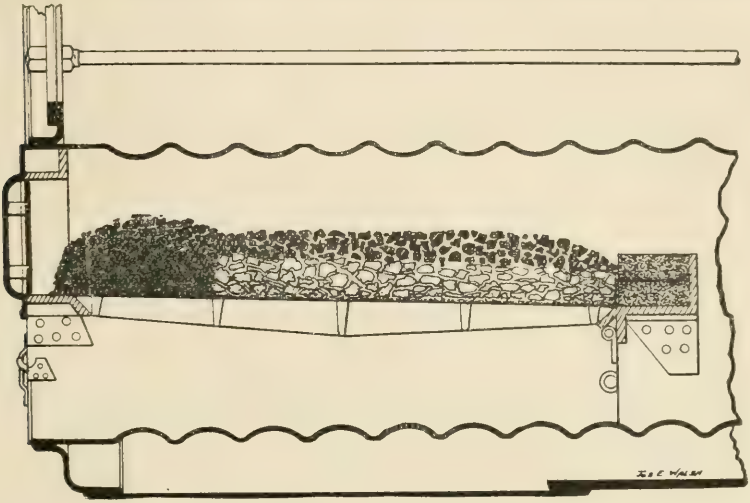


FIG. 3—SHOWING FIRE AFTER COKED COAL HAS BEEN PUSHED BACK.

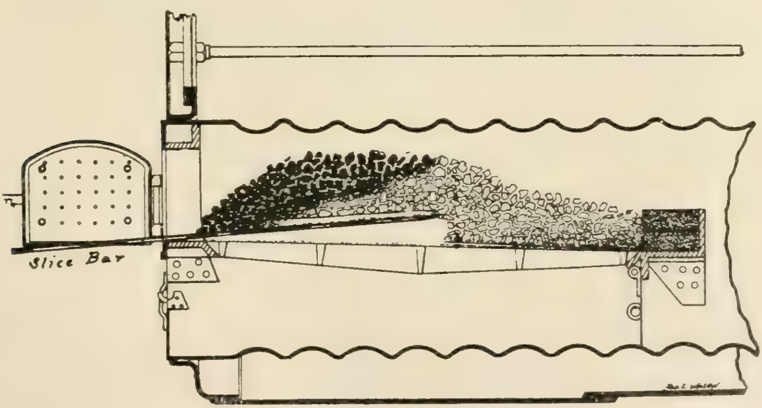


FIG. 4—METHOD OF BARRING FIRES.

Leave door cracked for short time and keep blower on until top of fire assumes bright red color. Regulate steam by damper.

Fig. 2 illustrates condition of fire before pushing back.

TO FIRE WHILE SHIFTING IN RIVER

A half-hour's notice or more should be given the fireman before getting under way in order to have steam enough to shift without forcing fires.

Raise steam by stirring top part of fire with rake and breaking up coked portion of fuel bed; crack door and use blower.

Allow fire to burn brightly for a few minutes; push back and put new charge on front of grate.

Repeat as often as necessary to hold steam.

To make additional steam in shifting, fuel beds may be barred if necessary, but this should consist only of a slight raising of the bed, not passing the bar up through it, as clinkers will mix with the fuel, spoiling the fire and making smoke. See Fig. 4.

Lumps of fuel charged should never be larger than one's fist.

Cracking of doors consists in doors being opened not over 1 inch and as they are opened for short periods of time only, the flues will not be affected.

While in the river, fires must be carried very thick at all times. If fires are allowed to burn down to 3 or 4 inches at the dock, it will be impossible to make steam without making smoke.

CLEANING FIRES IN PORT

Avoid, if possible, the cleaning of fires in port. If necessary to do so, clean quickly and when convenient, only one boiler during an hour.

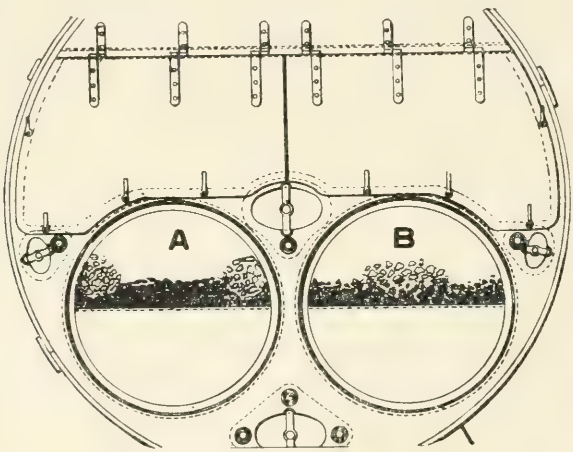


Fig. 5—*A*—Central Portion of Grate After Being Cleaned Out and Charged with Fresh Coal.

B—Wings of Furnace Cleaned and Charged with Fresh Coal After Central Portion of Fuel Bed Has Ignited.

Throw broken coal in front of wings of furnace on each side for a distance of 3 or 4 feet. Crack door and use blower. Wait until the last charge of coal is burning well, close ash-pit door; rake out in front all the old fuel on the central portion of grate and fill cleared space with well broken up coal to a thickness of 4 or 5 inches. If steam is not required, let green fuel catch and get well coked from the live beds at the sides.

To raise steam more quickly, the burning fuel at the sides can be winged over on top of the green coal. After either operation, open the ash-pit door and put on blower until fire gets action.

After the middle portion has ignited well, rake out the sides, which will be nearly burned out, charge with fresh, broken up coal and allow this to burn without winging over the center. Crack doors and use blower.

Fig. 5 shows condition of fire when cleaning by this method.

Give plenty of time for fresh coal to coke before again disturbing fires.

Do all cleaning and charging as quickly as possible in order to preserve furnace temperature.

STARTING FIRES

Cover bare grate with well broken up coal to an average thickness of about 4 inches. Then put five scoops of live coal on top at bridge wall, as shown in Fig. 6, and close fire door with damper open. Fire will burn from back to front with much less smoke by this method than by any other.

When fire has covered entire grate, push fuel bed towards rear and fill front of grate with fresh coal to about one-half the height of the

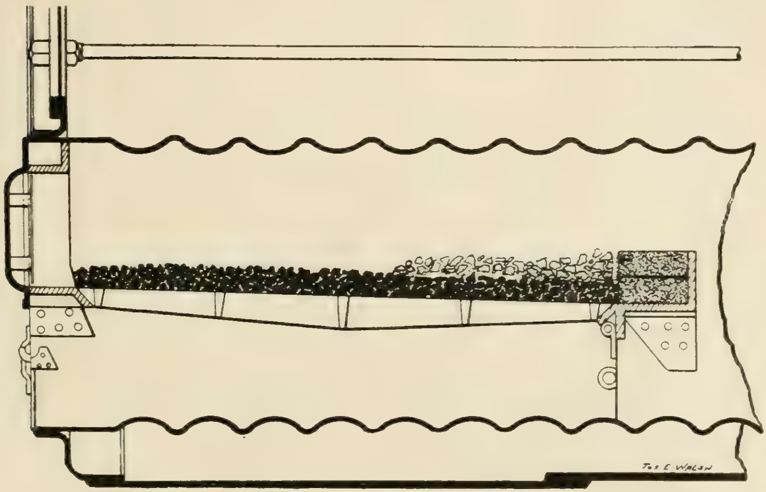


FIG. 6—METHOD OF STARTING FIRES.

furnace. This should be left undisturbed until mostly coked. Crack door and use blower. Shove coked coal back and repeat operation as often as necessary to raise steam.

In all operations where fire is disturbed, give fire a little air through doors and use blower.

BURNING POCAHONTAS COAL

This fuel cakes quite easily and to get the required steam must be broken up occasionally from the top; use a rake or hoe.

BLOWING FLUES

Flues should never be blown in the Chicago river.—MR. MONNETT and MR. OYSTER.

Profitable Sharing vs. Profit Sharing

By E. P. Roberts.

INTRODUCTION.

"Profit Sharing" implies an actual, or anticipated, profit or surplus, to share, and the term is usually applied to the sharing of the net profits of a business by capital and labor. In some cases, certain classes of labor, especially unskilled labor, does not participate.

It might seem that, logically, it should imply a sharing of losses. Practically it does not; and cannot, because labor cannot await the future.

Returns to capital *may be* negative, zero, or positive.

Returns to labor *must* be positive.

"Profitable Sharing" is the sharing of an accomplished gain. It is a positive result. The gain may be only a reduction of cost of a single element of total cost, and whether or not there is finally a surplus for distribution to capital is not a factor.

For "Profitable Sharing" capital furnishes not only the usual, or customary, facilities, but also special opportunity.

Labor furnishes the usual effort and *extra* effort.

Each participates in the benefit resulting from special opportunities and special efforts, and receives a share of the *earned increment.*

Profit Sharing industrial organizations, as above defined, have not been, as a rule, permanently successful. Personality, hope and trust have been factors, which have given a measure of success, but failure is probable when the basis is not fundamentally correct.

Profitable Sharing is the basis which has been most successful, and if it is correct fundamentally, and the writer believes that it is, then continued and permanent success can be anticipated.

Capital and Labor as Antagonists:—

That there is war between capital and labor is a fact. Such warfare is no longer of the spasmodic, guerilla type, but is systematically and intelligently planned and prosecuted. Moreover, those not actively enrolled as members of either party are seriously affected by the warfare.

War is an economic waste. A man who is selling certain supplies may not so consider it; though even his additional expenditures, taxes, etc., due to the war, may exceed his special profits resulting therefrom. Economic waste, however, is a term of general, rather than personal, character, and though frequently it is necessary to think in general terms, it is also often advisable to appeal to the individual.

"War is Hell", for *each* side. It injuriously affects *each* member of *each* side during the time of preparation for war, its active prosecution, and for many years after it ceases. It also injuriously affects neutral nations.

As capital and labor are each necessary to the other, why should they be at war?

Each possesses that which the other needs.

Each is willing and anxious to exchange, barter, or trade that which he possesses for a portion of the possession of the other.

To such extent as either party is dissatisfied, open rupture and war is probable. Dissatisfaction results in preparation for war, storing ammunition and supplies, and a readiness to take offense.

PROPERTY PURCHASE:—

After a purchase of property is consummated, the degree of satisfaction of either party, or both parties, may be immaterial, the incident is closed.

WORKING CONTRACT:—

A continuing, or working, contract, which at any time, or at all times, each party may, or does, desire to break, does not possess the one element essential for permanency, viz: the desire by each party for its continuance.

If one feature of the agreement is that a benefit to one will be accompanied by a benefit to the other; or, to state it differently, a beneficial result obtained by one will automatically be participated in by the other; then the probability of permanency is greatly increased.

UNIT:—

Although economic principles can be best presented in general terms and without reference to the individual, but it is the individual who must be considered ultimately, and, therefore, the individual is the real unit.

FUNDAMENTAL BASIS OF ACTION:—

Why does the individual do a certain thing or refrain from doing it? The answer certainly is, that the individual expects to benefit by the action, and to obtain a positive benefit from a positive action; or a negative benefit; that is, to avoid loss; from a negative action. The individual endeavors to obtain to a maximum degree that which he desires, and, therefore, *self-interest* is the controlling principle.

The foregoing use of the word "self-interest" does not imply that the person desiring to accomplish a certain object, either wishes, or is willing, to do so to the detriment of others.

Self-interest implies that in which the person is primarily

interested. It does not imply selfishness, which includes lack of regard for the rights or well-being of others.

Possibly self-preservation plus self-advancement describes the attitude of each party when considering the advisability of entering into a commercial contract.

It is of prime importance that capital and labor should co-operate on a fundamentally correct basis and then honestly live up to the agreement, or even without dependence upon honesty to have it *to the advantage of each* that the agreement be continued in operation.

An agreement on a basis that does not take human nature into account, or in other respects is not fundamentally correct, lacks the elements of permanency.

The foundation is not the entire structure, but the superstructure must be on a proper base.

WELFARE WORK:—

The writer desires to state that he believes in "welfare work" in connection with industrial organizations, and also believes that the inspiration for the introduction of benefits to employes is frequently philanthropic rather than financial, but it is the intention of this article to deal with the strictly business aspects of the relations between capital and labor, and to such extent as "welfare" is touched upon, to consider it entirely with reference to its earning value. Welfare work conducted on a man-to-man basis tends to health and contentment and, therefore, to permanency of force, and, therefore, it pays. If on a paternal basis, or a semi-charitable and semi-everything-else basis, it may be worse than useless.

ELEMENTS OR FACTORS IN THE SYNTHESIS AND ANALYSIS OF AN INDUSTRIAL ORGANIZATION:—

1. Capital is the money, or equivalent investment, required to furnish the facilities necessary to place the industrial enterprise in operation. The owners of capital can be considered as the agents for capital. If they are actively engaged in the business, they are also "Labor", and, therefore, their functions are dual, and should be so considered. "Labor" includes all workers, either mental or physical, skilled or unskilled and, therefore, it includes even the members of the Board of Directors, who, theoretically, are employed by the owners of the capital invested to labor in behalf of all.

For the purpose of this article, the author considers the divisions "Capital" and "Labor" more satisfactory than that advised by some writers on the subject, viz: "Capital", "Employer" and "Labor".

2. Capital and Labor are necessary to each other.

3. Self-interest is the underlying principle applied by each party when negotiating a contract.

4. "Capital" is the purchaser—"Labor" the seller.

5. "Capital" plans for the future—"Labor" for the present.

6. "Capital" can afford to wait for returns—"Labor" cannot.

7. A "Capital" and "Labor" contract is a continuing, or working, contract.

8. Capital is under no obligation to invest, but having done so, it cannot obtain results without labor.

9. In an industrial organization, capital and labor must together overcome an outside opposing force, viz: Whatever prevents the sale of goods—inertia of market, competition, etc.

The two forces, capital and labor, have a combined maximum when they pull exactly in the same direction. It should be noted that this is not necessarily equivalent to a maximum for either.

10. Maximum effort of an individual cannot be obtained without maximum compensation; maximum compensation cannot be paid unless maximum results are obtained.

11. Maximum effort of the individual is obtainable by making his compensation dependent upon the results *he* obtains.

12. The more subordinate the position of the individual, the greater becomes the importance of the following factors:

"A"—Necessity for frequent pay.

"B"—Necessity for immediate receipt of *all* that is due.

"C"—Necessity for pay based on results obtained by the individual, and, in decreasing degree, on the results obtained by the management.

13. Requirements for permanency.

Pay based on earnings, rather than pay irrespective of earnings and a gift added, makes for permanency.

The greater the desire by labor for permanency of employment under all the conditions, including that of opportunity, the greater the assurance of dividends for capital.

14. To formulate the proper conditions, and to maintain them, generally require a change of habits of thought, and of action. Habits are not readily changed, on the part not only of labor, but also of the representative of capital.

Perfection must not be expected.

15. Some one has stated that, "It is easy to float down stream, but that it takes a strong man to swim against the current."

Wisdom as well as strength are required, and it may be the part of wisdom to land on the bank and wait for the current to lessen, or, possibly, for the tide to reverse, and to recuperate while waiting. Or it may be better to float down the stream and endeavor to find a branch where the current is less strong, but which will lead to, or at least toward, the desired point.

16. To make progress, along any line, is similar to practice in gunnery, in which it is vital—

"A"—To *have* a target.

"B"—To aim accurately. This requires clear vision. Range finders may assist.

"C"—That the gun is properly designed and constructed for the work to be done.

"D"—That the ammunition is suitable.

17. Capital purchases everything but labor on minimum specifications prepared by the *purchaser*.

It usually purchases labor on maximum specifications prepared by the *seller*.

Why should not *results* be purchased and sold?

Coal is often purchased on the basis of what it can do, if properly handled. A bonus is paid for excess of useful elements, and if it is below standard, it may be rejected, or a deduction made at greater than the bonus rate. Why? Because to handle ash and clinkers requires additional investment and operating expenses. In fact, if the efficiency is not up to a certain mark, the fuel is practically worthless.

If coal has 15 per cent ash and clinkers, freight has to be paid on the 15 per cent. It has to be handled; it clogs the grates and consequently the air supply may be so reduced that even the good portion of the coal will not burn efficiently; more boiler capacity is required (more capital invested), and the ashes and clinkers must be removed.

Evidently the bonus above standard may be at an increasing rate (comparable with differential system for paying labor), or if the coal is below standard, it may be rejected.

Apply the principal to labor.

If coal is purchased by the ton, it is equivalent to paying labor by the hour.

If it is purchased on the basis of its productive value, with deduction for "dead" or injurious ingredients, then the basic standard is equivalent to the base output for a premium or bonus system; if it is above standard, the excess price or premium for additional value is equivalent to the premium paid labor.

If it is below standard, the coal, or the labor, is rejected.

(Note.—See later statement herein, relative to various systems of payment.)

18. View Point of the Man at the Top:—

Frequently it is stated that the man on a mountain has a broader view than the man in the valley, and an analogy is drawn between such conditions and those of the man at the top of a business organization, as compared with the condition of subordinates.

Are not the facts as follows?

The man who climbs the mountain and reaches the top, can see beyond the valley. He may not only look over the valley, but also overlook the valley. In some cases, when he reaches the top, fog obscures the view, or he may climb above the clouds,

and although potentially in a position to see everything, he actually sees nothing. If a telescope is used to study details, the broad view is lost. The greater the magnifying power of the telescope, the less the area in view. A general, or bird's eye view is desirable in order to ascertain relative position and importance, and it can be preceded, or usually preferably followed by a study of details. If the man at the top tries to keep a broad view and at the same time to study details, success is improbable, and the general view will probably be sacrificed. Moreover, the man at the top can only study details at long range by using a telescope, or if, in order to investigate, he descends, he loses time and energy.

It is important that the man at the top of a business organization should have a broad comprehensive view, though someone must examine details, and bring the *results* to him.

Generally speaking, the higher the position reached by the individual, the clearer is his vision as to matters which his eye has become trained to see. Visual selection is evident along many lines, and specialization frequently results in greatly increased power or facility to see certain objects, and loss of perception of others, even though in the same field of vision.

The ability to decide as to comparative values may be lost.

Some persons become color blind.

The geologist and the botanist, when obtaining their preliminary training, both see the same objects in the same field; later they will not.

Frequently a person high in authority may have an acute rather than a broad vision, or when looking toward the objective point, may use such a high power lens as to obtain great detail, but, consequently, limiting the field of vision.

The man on top considers that he is "it" and, possibly, that the man at the bottom is an "it".

The average employe, skilled or unskilled, is not only a human being, but is a good deal more of a man than many of those high in authority appreciate.

The man on top considers that the man below is not grateful. Why should he be? Has he not earned all that he received?

He complains that the man below will not trust him. Why should he? Has trust been earned?

Does not the man below read about contractors and labor unions co-operating to keep other contractors out of a specified territory? Possibly he has read about lawyers being engaged to get around the law. Is there any reason why labor *as a class* should trust the representatives of capital *as a class*. Confidence must be earned.

The man at the top complains, and justly, that a contract with labor is one-sided, and that he never can be sure that a strike, direct or indirect, may not ruin him because of change of labor conditions from those anticipated, *or agreed to* when he accepted a contract. He desires labor organizations to incorporate and complains because they object. The request is reasonable, but what would he do under the same conditions? Does

he endeavor to obtain laws which he considers injurious to him?

He complains because labor unions put every member on the same plane.

Does not capital do the same when it pays by the hour?

He complains of the inefficiency of labor. What has *he* done to make efficiency the basis of pay?

He may tend to consider that all trusts are *good,* or "reasonable" Trusts, except labor trusts, or unions, which he considers bad trusts. Is he not in any and every trust he can get into? Why were labor unions formed? Why do they exist? Have they not, as a rule, been at least as beneficial and managed with as much *respect* for the law as other trusts?

What reason has the man on top to view compulsory arbitration with enthusiasm?

Does not labor frequently make an exorbitant demand with the expectation that a board of arbitration will "split the difference"? Is that arbitration?

If labor is "received in" by capital, rather than "taken in", will not mutual interest in the one organization to which both of them belong lessen antagonism between the two organizations (Manufacturers' Association and Labor Union), which, at least to some extent, each joined in order to obtain protection from the other?

Is not the person highest in authority morally bound to be especially careful that his actions are on a high plane and above suspicion?

Will not one dishonest and untrustworthy "man on top" do more harm than can be overcome by ten men who deal fairly and squarely?

Is there any wonder that there are socialists and even anarchists?

If you have worked in, or close to, the ranks, and not forgotten; or if you have honestly investigated the facts; then your answer must be that distrust on the part of labor is only to be expected, and can only be overcome, as to any individual, or collection of individuals, by making a reputation for living up to the spirit and letter of an agreement, and *this takes time.*

Obedience may be obtained by the use of *force.*

Confidence must be *earned.*

19. View Point of the Man at the Bottom:—

What will I gain by hustling? The enmity of my fellows to myself, and, worse yet, to my family.

Why should I do more than the low limit? If the company has work, it will keep me on; if it has not, will it not discharge me? What does the boss know about my work, or any extra effort I may make? The foreman has favorites who stand first chance, if they have his good will, and my "best bet" is to stand in with him.

What chance have I with this company for increased wages or advancement? What is the history of the company in such respect?

The company officials may be all right now, but how do I know when they will be changed?

This new scheme of the company may be o. k., but guess I will go slow about it. How do I know what they really mean to do?

Speed us up and then cut us down? It has been done.

The company is an "it" to its employes, and this attitude of impersonality is fostered by some executives.

20. View Point of the Man Climbing:—

Evidently this is constantly changing. To a climber, the principal point is whether he will be allowed to climb, whether aids or obstructions will be offered him, and whether, if he "makes good", he will be *made good*.

21. Team Work vs. Co-Operaton and Co-Ordination:— Team Work:—

It seems to the writer that the comparatively recent use of the term "team work" as applied to co-operative efforts between the various units of a large and complex industrial organization, may have been productive of some harm by having given rise to a misconception. In most cases the use of the term has been helpful, and it is a more convenient and *intimate* phrase, than "esprit-de-corps", but the very fact that it is more intimate is the reason why, as sometimes used, it is of questionable applicability.

A "catch" phrase may be helpful, but if its application extends far beyond the limits of the conception which ordinarily arises in the mind when the term is used, then it may be harmful and give rise to incorrect deductions.

One definition of a team is "several animals hitched together to draw a load". In a team of such character maximum efficiency is obtained when each unit of the team has similar characteristics. For example:—A team of horses will do its best work when each horse has the same strength and also the same natural or acquired rate of speed. If the units of the team have different characteristics, then the maximum efficiency will be obtained by dividing the team into smaller units and hitching together those of one class. If one horse is unhitched and used to draw a load between the same places as before and for the same purpose, is such horse still "in the team"?

By expansion the term has been applied to athletic teams, but in "relay" teams, and some others, the result obtained is the *sum* of the *individual* efforts, and only to a slight degree, if at all, the result of co-oporation.

An analogy is frequently drawn between the various units of industrial organizations, and the units of a foot ball team, but the relations of the units of a foot ball team are exceedingly intimate and the efforts of each and all are directed toward reaching a certain goal, and generally the efforts are largely simultaneous.

It might be noted that the efforts of the units must be directed by one controlling brain, and this feature will later be noted at greater length, but the point to which attention is now directed is the intimacy of the relation.

Under industrial conditions it seems, to the writer, to require an undue stretch of imagination to consider the salesman on the road, the bookkeeper in the office, the machinist in the shop, and the laborer unloading coal, as members of the same team.

A college has numerous teams and each endeavors to win for the glory of Alma Mater. The general object is the same and all are members of the same body, and enjoy a far more intimate relationship than do the individuals of a large industrial organization, nevertheless, no one refers to team work between members of the foot ball team and members of the chess team.

Co-Operation and Co-Ordination :—

Co-operation and co-ordination between departments and individuals are requisite in order to obtain success, but, in the author's opinion, the term "team work" should be applied only to those intimately associated in an effort to obtain a certain specified result; the credit for obtaining this result being shared by all. If it is possible for one set of men to obtain such result, and then, or later, to have the credit or benefit taken away by some other set of men, then the two sets are not members of one team. Advancing the ball is a step towards a goal, obtaining a goal is a credited result. The factory end of a manufacturing organization endeavors to manufacture cheaply. If the selling force cannot sell the goods the factory is instructed to make, then the factory operators should not be penalized.

21. Type of Perfection :—

Is not the type of perfection the perfect and complete individual unit?

An omnipotent brain in an omnipotent body would be far more efficient than any combination of individuals, but because omnipotence does not exist, an effort is made to lessen inefficiency and inadequacy by co-operation.

If a foot ball captain could see and foresee everything and could instantaneously instruct each and every member of the team as to what to do and when to do it, better results would be obtained. It should be noted that time is lost in transmitting the signals necessary for even the desired co-operation.

An autocratic and perfect ruler would, in many respects, be preferable to a democratic government.

Such a business organization as a stock company endeavors to approach perfection by having a board of directors, who formulate policies, supervise general operation, etc., and the result is transmitted, in as nearly perfect form as obtainable, to the brain of the general manager, who, in turn, transmits it, at the proper times and with adequate instructions, to the working members of the body.

The *type* of perfection for the general manager and the working body is unity. One brain, and obedience.

Actual requirements necessitate sub-brain centers connected with the main brain, each receiving general and issuing detailed instructions.

Analogies may be helpful or harmful, depending upon how used; in no case is it wise to follow an analogy so closely and so far as to lose sight of the main proposition.

22. Payment for Labor Considered from View Point of Self-Interest of Each Party:—

What have been some of the plans for payment?

1. *Pay based on time;* hour, month or year. Why should such basis succeed? What incentive does it offer, especially to those of the class usually designated by the term "labor"?

It does offer an incentive for combination of labor against capital, and also capital against labor. A victory for either party is temporary, and the result is constantly increasing cost to produce, and economic waste.*

It merely gives labor a chance to exist, with a very evident and immediate penalty in case of failure, and only a slight and distant prospect of reward in case of being so successful as to reach a higher class; a 100, or 1,000 to one chance for common labor (physical or mental), and not vastly better for skilled.

Until data is obtainable, upon which to predetermine a rate based upon results, the time basis may be necessary. It is, however, a fact that frequently more data is available than is realized; as a new job does not have to be identical with one for which records are available, especially if such records are properly subdivided as to unit actions, or processes.

For unusual work, temporary jobs, etc., time basis is generally preferable. In all cases whilst payment is being made on a time basis, records should be kept in such form as will be helpful if a "result" basis should be installed later. A mere recording of gross and net results will prove of little value.

2. Pay Based on Results Obtained by the Entire Organization:—

"A"—*Profit Sharing.*

"B"—*Co-Operative Companies.*

"C"—*Opportunities to Purchase Stock.*

"A"—Profit Sharing:—

As generally applied, the term indicates that the net profits of the business are to be shared by all employes, or, in some

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*Recently a number of books and magazine articles have dealt in detail with the various plans for payment. A short, but comprehensive description, by A. B. Roberts, appeared in the Journal of the Cleveland Engineering Society, March, 1911.

cases, by all above a specified grade or by all those in the employ of the company a specified time.

Although many industrial organizations have started and continued on this basis with fair success, many have failed. The writer considers the basis fundamentally incorrect, and, therefore, if such is the fact, permanent success should not be expected.

It is a fact that its application is difficult, not only to plan, but especially to continue in operation on a permanent basis.

One party is in control, and, therefore, is subject to suspicion.

Capital properly builds for the future; labor necessarily for the present, or immediate future.

Capital has the whip-hand; and its agents and its policy may change.

It is difficult to obtain the confidence of labor and easy to lose it.

As labor must live, it must receive a living wage; it cannot share losses. During good times, it forgets the previous bad times for capital; and why should it remember them? It may have been worse for labor than for capital.

Employes are changing, and the employe of today is only, or at least primarily, interested in the conditions of today. Why should he be otherwise interested?

"B"—Co-Operative Companies:—

In some cases, the compensation to capital and to each employe has been based entirely upon profits obtained; in other cases, unskilled labor has been paid a fixed amount plus a percentage of the profit, or the former only.

A few establishments of the above character have been successful, though generally for a limited period. Failure has frequently resulted because of the limited vision and lack of experience of those lowest in the scale, the result being that the business management has not been sufficiently compensated, or has been unwisely hampered. To spend the surplus obtained during good times, or, when the plant is new, is natural and it requires such self-denial and knowledge of commercial conditions as are not possessed by most men in the ranks.

The rank and file who *elect* a captain are very liable to resent his orders, and not to submit to discipline. In a sense he is their servant. The "referendum" and "recall" are of questionable applicability to a fighting organization. An industrial organization is fighting for business.

This article deals primarily with manufacturing organizations rather than with mercantile, or distributing, companies. The growth of co-operative mercantile companies in Europe, especially in England, has been rapid, and is an interesting study.

"C"—Purchase of Stock:—

Some companies—notably the United States Steel Corporation and the International Harvester Co.—have offered employes special opportunities to become owners of stocks, and thereby

become, in feeling, "one of us". The purchase being on the deferred payment plan makes it practicable, and it is claimed that the plan has been productive of greater permanency of force and of personal interest in the company, its property and its results. Prompt adjustment of accident claims on a fair basis, old age pensions, and similar features of welfare work are also in operation in such companies, and each and all are of value. These companies do not claim that such features are gifts, but rather opportunities offered as part compensation and in addition to regular wages; in other words, that the benefits are earned by the participators, and that furnishing them, benefits the company.

In the writers's opinion, the factor *of prime importance is the basis of the cash payment.*

Payment in the form of opportunities of the class termed "welfare work" is secondary.

Opportunity for advancement is in a class by itself, and is of great importance.

3. Pay Based on Results Obtained by the Individual:—

"A"—Factory productive labor; physical labor; skilled and unskilled (or common) labor.
"B"—Factory supervision—superintendent and foreman.
"C"—Factory clerical force, draftsmen, etc.
"D"—Selling force.
"E"—General manager.
"F"—Directors, executive officers, etc.

(Note:—Section 12 might be referred to as introductory to the following.)

"A"—Factory Labor:—

Piece rate, differential, premium and bonus systems are all efforts to base pay on results, and have the following underlying principles, in addition to those previously stated.

Presuming that the shop investment (or the rent, if the building is leased) remains unchanged, then if the output can be increased the percentage of total cost which is represented by shop investment is lessened per unit of output.

The speeding up of men and tools will require the investment of time and money to start right, and may somewhat, or even materially, increase the clerical, inspection and supervision costs.

Labor cost is such a large percentage of total cost, and the inspection, supervision and clerical cost in connection therewith is such a small percentage, that the latter can be increased a large percentage to advantage if it results in even a slight percentage reduction in labor cost.

In order to "speed up", an incentive is offered in the form of "extra" or additional compensation for "extra" effort. Such "extra" compensation is less than the total saving, and is, there-

fore, beneficial to the man who provides the opportunities as well as to the man who does the work.

The basic idea of each of the above systems is that in order to obtain the best results for capital, the worker should be paid a varying amount depending upon the result *he* obtains, and, therefore, he will do his best, and capital will also benefit.

The fact is also appreciated that no one will continually do his best unless in some way his extraordinary, or more than normal efforts will receive compensation.

The fact is appreciated that each employe, skilled or unskilled, mental or physical laborer, must receive as a minimum wage an amount equal to that which the rank and file in his class receive for the same class of work when paid by the hour.

Also, inasmuch as each additional employe necessitates additional capital investment, in order to furnish facilities and work for such employe, therefore, if such employe accomplishes more than the standard task, capital is benefited.

If the foregoing statements are accepted, it follows that it is fundamentally correct to make it to the interest of an employe to do more than the normal task by making him a participator in the *earned increment* which he produces.

PIECE RATE:—

For a standard uniform product, piece rate is frequently applicable and advisable. It gives labor an incentive, and capital an increased output per dollar invested, therefore, each party benefits.

It requires great care to start right. Many errors have been made in rate setting, and are sure to be made when the ordinary method, or lack of method, is followed. The usual rate setting is largely the result of a guess, or opinion, and not determined by careful experiment and investigation.

Reducing rates without increasing facilities is a frequent source of friction, and not infrequently is unjust, and it is so recognized by labor. To "speed up" for the benefit of both, and later set a new standard for labor, and thereby change what was previously stated to be an acceptable basis of participation, requires, if friction is to be avoided, a better reason than the statement that labor should not receive more than a certain amount per day. A reasonable explanation should be offered, and if there is none, the employer must be prepared to take medicine of the same character as when labor breaks a contract. When it is agreed that at certain periods a change of scale will be made, the situation is, to a degree, improved, but, in any case, rate setting should be taken up carefully and not changed without a reason that will stand investigation.

Differential, premium, and bonus systems are based upon the proposition that in order to cover all costs, and possibly also to obtain a specified return on the investment, it is necessary that unit labor costs of each kind do not exceed a certain amount per unit of output, such cost being based on the results obtainable by

paying "going" or "standard" day wages. The "going" wage is made the base, or minimum, wage, and to such extent as any individual laborer increases his output above the standard he is paid a part of the resulting saving.

These systems differ in important respects, but the general intent of each is the same, and each has the advantage, as compared with a piece rate basis, that it is less liable to cause trouble because of incorrect rate setting.

Each is liable to require more clerical work than piece rate, but the total wages of the additional clerical, inspection, rate setting and production department forces are usually only a small fraction of the resulting gain.

To double a department cost, such as the production department (which possibly is only 2 per cent of total cost), and thereby reduce total cost 10 per cent (or far more), is undoubtedly wise, nevertheless, in practice, it is a serious stumbling block to some managers and directors.

"B"—Factory Supervision, Superintendent and Foremen:—

As these men are not directly productive, but directly supervise production, increased incentive to obtain decreased manufacturing cost can be based on decreased labor cost per unit output of the force supervised.

In the case of the superintendent, participation in the profits of the business may be an additional, or sole, incentive, especially if he is in touch with trade demands and may invent, design, or in any manner produce new or improved articles which may be "winners".

"C"—Clerical Force, Drafting Force, Etc.:—

Salary plus opportunity for advancement is usually the best basis.

A bonus, or a participation in profits of the business, may be paid, but recognition of effort and results by increased pay is generally sufficient to obtain maximum effort, especially if it is accompanied by fair treatment.

"D"—Selling Force:—

The commission basis, in whole, or in part, is quite customary.

"E"—General Manager:—

Payment based largely on profits of the business is logical, and usually desired, and desirable.

"F"—Directors, Executive Officers, Etc.:—

To such extent as they are investors their returns are necessarily based on results. Because the results they obtain may not be based on the profits of the business, but rather on manipulation, or the sale of the entire business at a profit (or loss), etc., is one reason why subordinates' pay for extra effort should not be on a similar basis to that of capital.

The salaries of executive officers, whether fixed, or a fixed

amount plus a variable depending upon the net profits, are practically dependent upon the magnitude of the investment, or interests at stake, as well as upon the interest earned on the capital.

3. Success for Capital, with Resulting Success for Labor:—

The objective point of capital is maximum net returns without impairment of capital.

A manufacturing organization has several general departments, such as manufacturing, selling, and general administration.

The manufacturing department is primarily interested in the cost of manufacture. Manufacturing cost is labor and material (prime cost) plus factory overhead charges.

Reduction of manufacturing cost may be obtained by:

1. Increasing gross output, which will result in lessening overhead cost per unit as long as such increased output is maintained.

2. Purchase of new tools, thus increasing the output per individual and thereby reducing labor cost per unit.

3. If raw material can be purchased cheaper it will, of course, reduce manufacturing cost, but a really large percentage of saving in this manner is seldom possible.

4. Labor cost may be reduced by cutting wages, or by increasing efficiency of labor and thus reducing the *labor cost per unit* of production. This last method is the one which frequently has been neglected, and, nevertheless, which generally will produce the greatest net results. This is "intensified production".

A study of manufacturing organizations includes a study of the possibility of development of new tools, appliances, methods of operation, etc., to obtain better results, or to lessen the manufacturing cost, or both. It also includes a study of the possibility of developing new or improved articles for sale. An analysis of the market and of the selling department, and finally of the general administration, is also required.

Analysis of losses is frequently of great value.

It is also important that the market conditions be accurately ascertained and analyzed, including the study of such matters as—

What the selling price has been and what it is.

In what markets the salesmen have been most successful.

The profits or losses on various classes of goods.

The possibility of developing existing markets.

The possibility of new markets.

The possibility relative to marketing new classes of product, usually allied to those already manufactured.

What the competitors have done.

23. As this article is relative to labor, it will be closed by presenting an example of "Profitable Sharing".

EXAMPLE.

Total cost of goods sold annually, including selling costs		$100,000.00
Total received for goods sold		106,000.00
Capital invested	$100,000.00	
Surplus	6,000.00	
Rate—6 per cent.		
Labor 30 per cent of total cost		30,000.00

PROFITABLE SHARING:—

If labor is reduced to such extent that it would equal a reduction of 20 per cent of former labor cost, if paid at the old rate, and if one-half the resulting saving be paid to labor, then the actual resulting saving to capital will equal 10 per cent of $30,000.00, or $3,000.00.

The surplus then becomes—$9,000.00.

Rate—9 per cent.

An increase of 50 per cent for capital.

The labor under the new conditions is only 80 per cent, numerically considered, of that formerly required to obtain the same output, and labor would have obtained,

At the old rate—$24,000.00;

and now obtains—$27,000.00,

an increase of $3,000.00, which equals 12½ per cent.

If in the above the capital is all represented by stock, then the stockholders benefit in the amount and ratio of income stated. If, however, one-half the capital is borrowed at 6 per cent, on bonds at par, then the bond interest must be paid before the stockholders obtain any benefit. The stockholders' risk is, therefore, increased, but also the possible benefit, and, on the other hand, the stockholders may lose all their investment if the business does not succeed and the property is sold to satisfy the mortgage. Evidently labor should not be affected by the financing plan, and, therefore, under this condition the labor benefit is exactly the same as under the first condition, but the stockholders benefit in an increasing amount and ratio.

It should be noted that, although in the foregoing example the division of the "earned increment" is assumed as divided equally between capital and labor, nevertheless, the rate of increase for capital is in a far great ratio than for labor.

This might be claimed as unfair by those who claim that there is a fair, equitable, arbitrary *and fixed* division of profits between capital and labor, but, even if such were the fact (which the author does not believe is the case), nevertheless, it is a generally accepted principle that the one who takes the greater risk should, in case of success, reap the greater benefit.

A business investment is more or less of a risk, and the degree of risk is generally somewhat in proportion to the hoped-for returns. The man who conceives and risks, dares and wins, should be considered as having some special rights, but even to put it on the plane of selfishness, the public cannot expect to ob-

tain the advantages which may accrue to it as the result of skill, daring and risks, unless it gives the person who initiates and risks a chance to obtain something more than if he had put his money into a Savings Bank and his ability into cold storage. The exercise of ability may be worth far more to the development and to the public than the investment of cash.

24. Conclusion :—

Self-interest is the controlling factor in making an agreement, and continuing to work thereunder.

Capital initiates?

Capital desires maximum returns without impairment of property.

Capital requires labor.

To obtain maximum results from labor, capital must, broadly speaking, satisfy labor.

Labor of all kinds and any kind, mental or physical, will trade average effort for average returns, and *extra* effort for *extra* returns.

The extra returns must be considered as earned, not as gifts, whether paid in cash for work done, advancement because of results accomplished, or partly in the form of advantages of such character as termed "welfare work".

The cash payment is to the average worker the feature of *prime importance.* Any feature which tends to contentment with conditions, and, therefore, to permanency, and also which increases health, and, therefore, ability to work, is of great importance.

There is no inherent reason why the basis of *profitable sharing* should be the same for all classes of employes, from directors to common labor. Payment according to results obtained by the individual is desirable, *to as great a degree as practicable.*

The laborer in the shop can only affect his own output; therefore, his pay should be based on same.

The man "at the top" affects all results; therefore, his pay should be based on the net results of the business.

25. The Superstructure :—

Before closing, I desire again to call attention to the fact that the foundation is of prime importance, but it is not the whole structure.

"Self-interest" may be considered as a cold-blooded basis, but how can the basis of the contract be otherwise? Capital is one party thereto and is merely active wealth and is inherently soulless, and also that which it purchases is defined in terms of time or results, more or less concrete, and not in terms of sentiment.

So much for the basis, but the relations between the human beings who are respectively the agents of capital or of brain or physical energy, are affected by sentiment.

If it is granted that self-interest is the controlling factor when entering into a contract and for continuing to operate under

same, nevertheless, there are times of stress when sentiment may even control.

The writer certainly believes that the application of the highest qualities of the mind and heart—justice and kindness—on the broadest basis is necessary if the maximum result is to be obtained, not only results to humanity, but also to the specific business.

1. Is the basis of the agreement.

2. Each party should do his part—up to the letter of the contract—justice, legally considered.

3. A broad-minded, manly justice, which recognizes not only the letter, but also the spirit of an agreement, and, sometimes, even goes farther and recognizes that changed conditions justly demand modification, or reconsideration, of a legally enforcible agreement.

4. The calling into service of all the highest attributes of manhood will bring beneficial results to any organization. Men who *are* men will obtain loyalty, and loyalty in an industrial organization is as essential as in an army. A live industrial organization is a fighting organization, and, therefore, internal dissatisfactions, jealousies and dissensions must be injurious.

5. Though financial consideration must be taken into account by the representative of capital, nevertheless there is something higher and finer than earning money dividends. There are many men who desire to earn dividends not only for themselves, but for all those with whom they are associated, and who have the real and permanent good of all at heart. The basis of a legally enforcible agreement must be sordid—the practice need not be.

Discussion

W. S. Stone:—

Mr. Chairman and gentlemen, I don't want to get started on the labor problem. It is too late in the evening. But I don't agree with the fundamental statement of the gentleman who addressed you, that is, that there is a war between capital and labor. There is no such war. Capital is simply labor stored up and utilized. Each is dependent upon the other. Neither can exist without the other. Therefore, there is no war between capital and labor.

Neither do I agree with his statement in regard to much of this welfare work. I think a large number of us stumble at the word "welfare work", and I think it is a misnomer. So much of this welfare work reminds me of trying to bail out a leaky boat instead of stopping the leaks. I think if we would handle the labor problem differently, we wouldn't need so much welfare work.

Regarding the question of efficiency, I know that is one of the late fads. You know we have these things in cycles. Everything now is efficiency. The Brotherhood of Locomotive Engineers has stood for efficiency for the last forty years, and I believe the records of the organization will bear out my assertion. But, is it not a fact that the American workman of today produces more than any other working man of like class in the world? I think he does. Isn't it also a fact that we are speeding up the machine, that the cry is constantly faster, faster? And what is the result? We are simply throwing men on the scrap pile at an age where they used to be at their best, and it is all due to this cry of efficiency.

The great trouble with our efficiency is that the Supreme Power, when he created man, endowed him as a human being, with all a human being's faults and whatever else goes with it. He didn't make him a machine guaranteed to make so many revolutions and produce so much a day, and the time never will come, although it is a beautiful theory, when every man will be 100 per cent efficient. I heard a gentleman talk, not long ago, before a large audience in New York, and he had a very beautiful theory, which was to double the output of the whole work. His plan, roughly stated, was to discharge 50 per cent of the employes and make the other 50 per cent do the work.

The greatest trouble in the labor world has been with the piece-work problem. Our locomotive engineers are mostly piece-work people. The trouble with that system in the shops is that you will always put in some men who, through some special efficiency, can produce more than any other man in the shop. He becomes a pace-maker, and as soon as he produces more than the employer would consider the normal output, he immediately scales down the wages; that man is earning too much. That is what has brought about the objections to the piece-work system throughout the country.

Another thing, in all these beautiful plans about 100 per cent efficiency, I have the first man yet to tell me who will take care of the man that is not 100 per cent efficient, never can be and never will be.

I believe in having things systematized, but in my experience in handling the labor problems for the last twenty-five or thirty years, I have run across, occasionally, too much system. It reminds me of the gentleman who put in a new filing system. The agent came around two or three weeks later, and said, "How is the new filing system working?" "Oh, fine, good, good." "How is business?" "Oh, there isn't any business; it takes all the time to look after the filing system." That is true of some of our systematized shops; they systematize clear beyond the point of economical administration.

The labor union, in some form or other, has come to stay, and in some form or other employers of labor will have to reckon with it. It will probably change; it is gradually changing to meet changed conditions. But back of all this stands this one

thing (to those who fight against labor unionism and try to destroy it), first of all I am an American citizen, and then I am a labor union man—if they could have their wish and destroy organized labor, I know of no worse calamity that could happen to this country. All that stands between wealth and the wave of anarchy that would sweep over it, is the conservative labor unions such as I represent.

E. E. Ranney:—

I was very much interested in Mr. Roberts' paper. As Mr. Stone said, we are all spurred on in the present day by the question of efficiency. I have had the bee, I guess you might call it, of trying what could be done to spur on, but I must agree with some who have given it considerable study, that we don't find all people 100 per cent efficient. And I imagine that we have got to give the human element more consideration than we, in our own minds, are willing, when we get down to discuss the question, to give it. I expect that all employers of a large amount of labor feel that it is necessary to try to elevate the efficiency of the force, because, as we gather from here and there and all over, we get into our organizations a considerable number of, you might say, unskilled laborers. With us, we find considerable trouble in getting individuals to work up to even 85 per cent, as we figure it. But it is a pretty broad problem, and not having considered the discussion of the individual paper, I don't know as I want to get into it very deeply. In fact, I am not prepared to.

Willard Beahan:—

I am not at all qualified to speak on the relations of capital and labor. I have always been a laborer, working on a salary; and while I have been very much interested in the paper, I do not feel qualified to discuss it. There are some things that we talk about a little in the railroad world and then admit that we know little about them after all.

My particular work, of course, is handling other men for the company, myself one of the employes. I am aware of the fact that George Stephenson, the father of engineering, laid down this broad law, that some of us have gotten too far away from, that "The highest form of engineering is the engineering of men." We make plans and compute stresses, we design various things, but as engineers, we have gotten entirely too far away from the handling of men. I am sure the engineers here tonight will agree with me in that we have turned over too much the handling of men and the execution of the work to some superintendent or foreman whom we have only partially trained.

I am one of those old fashioned fellows, although I was born recently, who love to get back to the idea, but not to the phrase, of Master and Servant, as used on the other side of the water. In my own experience in handling men, which has never run beyond two thousand, and generally not over a hundred or two, I find that if I can put myself in the place of the master, as when we used to have apprentices, I get on better. I like to be considered a kind of a stepfather to the men working under me. If they have trouble, I want them to come to me, and always, if they borrow money, I want them to borrow of me. I have never lost a dollar in the world which I expected to get back. When the men get into trouble, I want them to come to the "old man"—it is a pet name for me, and was before my hair got the least bit white. I like them to have that attitude toward me. I want to listen to their troubles, help them to fight their battles, stand between them and the company and between them and their superiors at all times.

Some will tell you that I never had a strike. I never had a strike that got very far; I always had friends enough in the force to help stop it. I believe in treating the other fellow as one likes to be treated. I have worked engineer parties a long time and under very trying privations and dangers, and I never had a man quit on an engineering party. I never had a man on those parties ask for more salary or for less work. It is a proud fact for our engineering profession that that is the way we have trained men. I do feel that if we can get back to that old idea of master and servant, or the old man and the boy, as we used to be when the boss paid the man out of his own pocket, we would all be better off. If we could in spirit get back to that old idea in our big corporations, dividends would be surer. That is my idea of the engineering of men. With that system the efficiency largely takes care of itself.

I agree perfectly with all the gentlemen that capital is simply accumulated labor and that each has its rights. I am very sorry that the rights of capital have not in recent years been much respected, nor have the rights of labor been always respected. But the average American can be trusted. I believe in him very much, and so long as we have the right to vote and freedom of speech, these things will adjust themselves. This is a very interesting and a very critical age. Let us think, talk it over together, *then* act.

A. J. Himes:—

I don't see why the chairman should call upon me to say anything about the compensation of labor. I am sure he never saw me work, and never looked at my hands to see whether they were calloused. Perhaps having no experience in labor, he thinks I am better qualified to talk about it. If not, the rest of you may think so when you hear what I have to say. I expect you

to say of my remarks that they are ideal and impractical, that is what is always said of any new application of science to the useful arts, but I expect that this gathering of professional men will listen patiently and attentively to what I have to say.

I have always found, in approaching a difficult problem, that the prospect for its successful solution was much brighter if one had a thorough understanding of the principles involved. It appears to me that in the compensation of labor the fundamental principles are Leadership, Evolution and Kindness.

Of leadership, I would say that all human society is divided into little groups, colonies, as the student of bacteria expresses it. The astronomer thinks of the heavenly bodies rotating about a central body, each in turn having its series of satellites, down to the last moon. So the head of a family is a leader, the teacher is a leader, the preacher is a leader, the foreman is a leader, the superintendent, a president, a mayor, a governor, the president of the United States is a leader. The foot ball coach, an officer of the army or navy, or a king is a leader. A very clear understanding of this idea of leadership can be secured from the reading of Carlyle's "Heroes and Hero Worship", in which it is pointed out that all mankind, from the beginning of things to the present day, is disposed primarily, inherently, to seek out and select for itself a hero, someone to follow, some person, some being whom he would seek to emulate. This element of leadership is one of the fundamental principles to consider in dealing with labor, or in dealing with human society.

The second principle is that of evolution. It is not so long ago that the scientific world was very much in doubt as to the correctness of the principle of evolution as enunciated by Darwin. Today I believe that Darwin's theories are quite generally accepted in the scientific world. As applied to a solution of the labor problem or the relations of the employed to the employers, I would call it a progressive development, limited by the term of life of the average individual. I remember very clearly of reading, when a boy, a book which was written by a preacher who went by the name of Adirondack Murray. Parson Murray was the discoverer of the healthful climate of the Adirondack mountains. He spent much time up there, and recites in his book many conversations which he held with his guides on various trips throughout the Adirondack region. I remember a particular instance, in which he described the attitude of his guide toward the development of his family. The guide explained how his father and mother had been pioneers in the land, how they struggled through great hardships to acquire a competence, and were able, through their unusual exertions, their privation and their hardships, to give their children better starts in life than they themselves had received. And the guide explained how he in his turn had been favored by fortune and was able to give his children a still better start in life than he had. Parson Murray said that was the ideal condition for American citizenship. That is progressive development. Each American citizen likes to do a little better today than he did yesterday, and

a little better tomorrow than he did today. If he has been accustomed for a long time to smoking five-cent cigars, he likes, once in a while, to smoke a ten-cent cigar. Maybe he aspires to a fifteen or a twenty-five-cent cigar; I don't know; I don't smoke.

This progressive development is one of the fundamental principles to consider in dealing with the problem of the employer and the employed.

The third principle is that of kindness. The law of kindness ought to be a scientific law. It is not given space in the text books in technical schools; perhaps it never will be, but it is true that some two thousand years ago, in a little country in Asia, called Palestine, a man enunciated a law which has ever since throughout the civilized world been accepted as the acme of, I was about to say human wisdom, perhaps Divine wisdom, and yet, we have given very little attention to making use of this law in a thoroughly practical, intelligent and scientific manner. I suspect that whenever the fertile and active brain of the technically educated young man is directed toward the application of this law to the same extent that he has studied and sought to apply the law of gravitation as enunciated by Newton, some very marvelous results will ensue.

Consider for a moment the great torrent of water that for countless ages has poured over Niagara Falls. It has been a grand natural spectacle, a source of wonder and awe to all beholders. Well, after the introduction of the art of printing and the occasional discovery of some great scientific truth and the wide dissemination of scientific knowledge, there was loosened upon the face of the earth a great multitude of bright and active minds, that I might compare in a way to what escaped from Pandora's box. They are actively engaged in seeking to apply in all conceivable directions this scientific knowledge which has been brought forth by our first men. And finally at Niagara Falls the engineers came along, and built an intake, with head gates, a shaft, a wheel pit, and a tail gate, and then they built a tunnel in the side of the gorge and installed a set of electric generators. Then they constructed a transmission line and carried the energy developed by the generators by reason of the law of gravitation, the wonderful force which we term, for lack of any other name, electricity, conducted this force hundreds of miles away to be applied, through small electric motors to various mechanical operations.

Now, this long process of thought, which finally has brought forth such wonderful, such marvelous, such inconceivable results, results of which we engineers have the faintest possible conception, have very little understanding—whenever a like amount of thought and energy and study has been expended upon the application to the useful arts of the law of kindness, I think that the results in our human society will be no less marvelous and wonderful than those which are following the utilization of the power of Niagara Falls.

So, while I haven't helped out in any way those who seek

the detailed management of their factories, or other large institutions where great masses of labor are employed, I have pointed out a line in which for some time my thought has been running, and in which I look for future great developments. It is true that my friends in Cleveland haven't seen me engaged in manual labor, unless they happened to live in my neighborhood and were awakened early last winter by the sound of the axe in my back yard. I like to swing an axe; there is a great deal of pleasure in it—perhaps because I have to do it so seldom. When I was younger, I spent some time in agricultural work, and I never, on any occasion, of which I can remember, felt that it was in any way distasteful or uncongenial. I think that severe physical exercise is a joy and a delight to an active, healthy, strong and vigorous young man. He may have other ambitions, he may want to be something else, but the utilization of his surplus energy is always a pleasure to that sort of a man. I do not think that our American citizens despise labor. I think that many times they feel uncomfortable because others, with whom they come in contact, appear to despise those who labor. There should be a revolution in our social affairs. The highest honors should be given to those who labor hardest, those who struggle most sincerely, most earnestly and most strenuously for the uplifting of their fellow men.

ROBERT HOFFMANN:—

Mr. President, I can hardly understand why the chairman should have called upon me to take part in a discussion on profit sharing. Like others attending this meeting, my connection with labor and the employe has not been of the type that admits of the consideration of any profit sharing, since the disposal of profits does not fall under my jurisdiction. In that phase, municipal engineers differ entirely from manufacturers.

The paper of the evening has been very interesting, and, of course, any one who has others in his employ or is called upon to direct the work of others, must at times have some of the thoughts expressed in the paper on "Profit Sharing" brought to his attention. One thought especially has come to me, and probably to us all, and that is, where proper interest is shown by the employe in his work, and there results certain fruit in the way of profits from collective labor, all who participate ought to share in the distribution. There is a great difference in employes; one will manifest an interest in his work, another scarcely any, or none at all. A man's time is paid for and it seems he should serve his employer to a degree which is right and just. When, therefore, an employe does manifest an interest in his work, shows a love for it, and is willing that his labor should result in a benefit to his employer, he certainly should receive some consideration other than that given to the ordinary man who is satisfied to give only his time and take no interest in his work.

If, therefore, it is possible to, in some way, measure this added interest, it seems quite logical that it be rewarded by an allowance from the resulting profits.

E. P. Roberts:—

Gentlemen, the paper had two objects, one to ascertain what object should be aimed at; the other was to present a paper which you gentlemen could shoot at, which I think a number have done admirably.

I made a few notes. One of the gentlemen stated that risk to capital was of the past. With all due respect to the gentleman, if he were endeavoring to promote a new enterprise, presumably beneficial, he would not make that statement so broadly, or at least would qualify it in some degree. At the present time, to a very large degree, capital is not active; it is inactive wealth and is not earning, and it is almost impossible to put through a new enterprise. Public service corporations of all kinds are so uncertain as to the outcome, so uncertain as to the degree of regulation which they are going to have, that they hesitate. I happen to know personally of enterprises in several states, which are tied up because capital is afraid to invest. It is very difficult to know what is going to happen. It reminds me of a speech made in this hall last winter by a gentleman who went from St. Louis to study conditions in Europe, relative to accidents in industrial organizations, and the point was brought out that it was not necessarily vital to know that an employer was going to be held liable, but of prime importance to have the degree of damage liability fixed. The point arose in connection with the plan to have all employers and employes held responsible for accidents, a mutual plan with governmental control. Employers would then know what the conditions would be. It is a lack of knowledge as to what the regulation is going to be, that prevents the public service corporation today from making the improvements and from going ahead and developing new properties. I claim most decidedly that the risk is not of the past.

Now, relative to welfare work, one gentleman made a pretty strong statement against welfare work, and some of my statements were along that same general line, and I believe that a lot of welfare work is even worse than useless. It is a namby-pamby kind of paternalism, and is not needed, but some of it is manly, straightforward, helpful work. That labor unions have come to stay was another statement with which I most decidedly agree. They are not perfect. The manufacturers' associations are not perfect. Neither are perfect, because we, as individuals, are not perfect, but we must *aim at perfection*. How shall we do it? It seems to me we have the best chance of winning if the basis takes into account human nature, and, therefore, I suggested that anything but altruistic attitude, that of self-interest. I believe that even if we follow along that line, far better results

can be obtained than are usual today, but no one need stop at the foundation, and I did advise climbing.

Another statement was made relative to 100 per cent efficiency. As I understand the proposition, it was not a question of 100 per cent efficiency, but of putting the wrong tool to work. A locomotive engineer might object if the fireman was jumped up in about one or two months to the right-hand side of the cab and one would not expect 100 per cent efficiency from such man in such position. The proper procedure is to pick out the man suited to the work and then develop him so he can do that work better, if he can be developed to do a higher grade of work, then you secure something still better.

One of the speakers made a statement that a great deal of the labor is only from 30 to 50 per cent efficient. We know that a great deal of labor is inefficient, partly because there is no incentive and partly because there is no proper facility or equipment, and often because there is no adequate instruction.

Relative to the statement that by increasing effieciency, and therefore the work would be done by fewer men, and those least competent would be discharged to become a burden upon the community, and therefore efficiency was not desirable, I would merely refer to the history of improvements and the generally beneficial results. That improvements are sometimes injurious to individuals is a fact, but there must be continual advancement. Possibly I did not understand the speaker correctly, as I do not believe that he would object to improvements in machinery, or in methods, or along any other line.

A statement was also made relative to kindness. It seems to me that the phrase "Do unto others as you would have them do unto you" signifies justice fully as much as kindness. Justice is certainly of prime importance, not merely legal justice, but just dealing.

As to there being a lack of knowledge of what is going on in manufacturing establishments, we all know that it is often true. One speaker referred to a peculiar condition. Mr. Beahan also referred to it.

I had occasion, some little time ago, to investigate a manufacturing plant. The officials claimed that one department was losing. An examination of the records showed that the overhead charges were improperly distributed. The net result of the investigation was that that department was making a higher rate in the investment than any other department.

Now that the efficiency engineers have been having an opportunity to get a whack at it, a good many seem to think that they have *discovered* "efficiency". There has been a rush of efficiency engineers without sufficient experience to qualify them. They have certain principles fairly well in mind. They have the card system and other equipment features, but they don't see what the effect of rate setting, or some other modification of a department (which may be all right in that one department) will have on the whole proposition. Their view is not broad enough. Another trouble is that when these men are competent.

they don't give sufficient time, or are not allowed to give sufficient time, or are not compensated sufficiently to give it, to really investigate the proposition. There is too much hurry. The placing of an efficiency system in an ordinary manufactory means a lot of preliminary work, and going slow, and not being in too much of a hurry. Get your aim high, but go slow.

Not long ago, I was in a factory in this city. The superintendent pointed out a man and said, "Now, that man is making 'so much' a day at the piece rate, which is more than his foreman receives. We put him on this job and he cannot do anything like as well at anything else, and no one can do this job as well as he can." They didn't cut his rate. The superintendent said they took their medicine.

In a certain sense, they did have medicine to take, and in another they didn't. They were perfectly willing to continue his pay, but the result was that everybody else complained. Here was a comparatively unskilled laborer, making $4.00 or $4.25 a day, and others throughout that department of the factory objected because they didn't have the same opportunity.

Another case I noted in New York, not long ago. The man who set the piece rate did it after careful consideration with the superintendent and the foreman, and they stayed down one or two evenings and did the work themselves. Two of the three men were competent machinists. Nevertheless, when they set that rate, the man complained; he said, "I can't reach that minimum." But they said, "Go ahead and try, we will pay you the minimum rate." In a month he was 50 per cent ahead, and in another month he was 100 per cent ahead. It made trouble in the factory. It showed that the rate was not a desirable rate under *all* the conditions. As a general proposition, that is about what would be expected.

The Relative Economy of Gas Engines and Other Sources of Power.

By J. B. Meriam.

Perhaps technically the purchase of a kilowatt of current from a corporation may not be considered as a source of power. Yet it is a means of obtaining energy, and should be considered.

The representative of a corporation, or an illuminating company salesman, as he is usually called, will tell his prospective customer that the fuel bill will be a very small part of the cost of his private power plant, and that he must add to this 6 per cent interest, and from 15 to 20 per cent depreciation; 10 per cent for obsolescence, a percentage for overload; a charge for floor space used; a share of the general manager's and the superintendent's salary, 3 per cent insurance, oil, waste, water, and to be safe he should set aside a sinking fund of 5 per cent to cover cost of repairs, and liabilities of accident.

If his statements were true, few, if any, could afford to put in their own power equipment. The wise factory manager will rather ask himself "What extra charges, that I have not already, will there be if I put in my own plant.

"I must hire an engineer, but he will be worth half his pay in caring for the elevators and other machinery. By making a better arrangement of my basement, I can make room without extra cost. I must pay my superintendent whether I put in a plant or not. If there should be such a wonderful invention as to make my engine obsolete and worthless within a few years, I will be but the better off for it, so I can see no use of a charge for obsolescence. I can borrow money at 6 per cent, and there will be a difference between my running expense and the cost of buying current, of fully 30 per cent on the investment, to cover depreciation and profit." He will surely put in his own plant.

There are certain problems to be solved in the maintenance of a private plant, and it is less trouble perhaps to purchase the current, but there are often advantages in the private plant, which, although incidental, are worth the full cost of operation.

Particularly is it worth while to consider the fact that the private plant, when used for lighting, has control of the voltage or quality of the light.

The current furnished by most lighting companies varies in voltage with the rise and fall of the power load curve. Since all customers demand light at the same period of the day, the quality is poorest when the light is most needed. It is not possible to raise the voltage at the station or transformer more than a very limited amount, as it would work damage to those nearest the central station. When the voltage drops below normal, the

efficiency of the lamp is greatly lessened so that the customer does not receive full value in light from the kilowatt hours paid for.

The owner of a private plant may regulate this voltage of his current at will and in comparison his store or place of business will appear in brilliant contrast to that of his neighbor. This is worth very much by way of advertisement.

As an example of this condition, I am pleased to cite the store and plant of the Rhodes Drug Co., of Youngstown, Ohio. The store is located on one corner of the Square. The private plant consists of but one 15-horsepower twin-cylinder, vertical gas engine, direct-connected to a suitable generator. Not only does Mr. Rhodes brilliantly light his own store with his engine, but supplies current for two or three electric signs, the revenue from which pays the entire operating cost of his power plant, which is but a few dollars per month.

Mr. Rhodes states that the distinction of his brilliantly lighted place of business is in itself, as an advertising medium, worth several times the total running cost.

All of these elements should be carefully considered to determine whether a source of power is the most economical.

Having decided to install a power plant, the next question is of a prime mover which will pay the best returns on the money invested. We have to select from, the hydro-electric, steam turbine, steam engine and gas or oil engine. Water power is ideal, but not often to be had at any price. The steam turbine is more suitable to large installations, and the question lies between the steam engine; the gas engine, and the purchase of current.

In the discussion of this subject tonight, anything which may be said of steam engines will be in general terms only, the time being devoted to some of the accomplishments of gas and oil engines, and even these limited to power plants of moderate size.

It is admitted at the start that the purchase price or first cost of gas engines will be greater than that of steam-driven power plants, even with boilers included. Why the cost should be so much higher is the most common question asked by the prospective purchaser, and it is worth our while to here consider it.

In the steam engine the piston, and all of the parts for the transmission of energy, receive two impulses at each revolution. In the single-acting gas engine cylinder (Fig. 1) there is but one impulse for *two* revolutions. It is then true that in the development of the same mean effective pressure, four cylinders will be required for the gas engine, and but one for the steam engine.

Other things being equal, the cost of the gas engine cylinder must be four times that of the steam, but other things are not equal, and are still to the advantage of steam. To secure the same mean effective pressure in the gas engine cylinder, the maximum explosion pressure will reach fully three times the boiler pressure of the steam engine.

Every transfer of energy entails a loss—in the steam plant

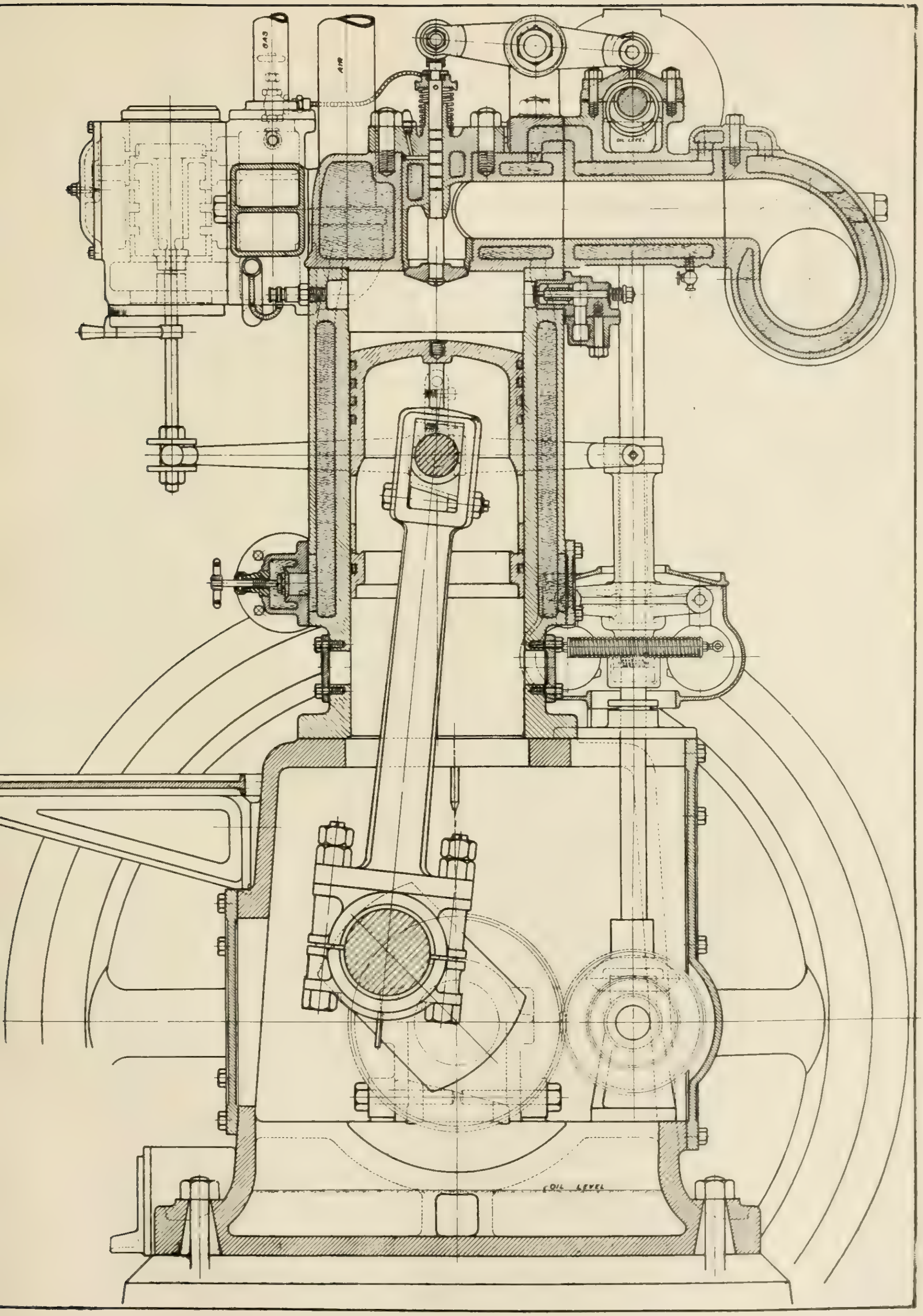

FIG. 1.

we have the chimney losses, radiation, leakage, latent heat of steam, and heat of exhaust, so that we are able to obtain, as you well know, but from 6 to 12 per cent efficiency.

In the internal combustion engine we have heat lost to water jacket—25 to 30 per cent, radiation 4 to 5 per cent, and exhaust 40 to 45 per cent, giving a net economic efficiency of from 20 to 30 per cent, or fully twice the highest efficiency in the best of steam engine practice, and from three to six times as good as is obtained in practice where non-condensing steam engines of moderate horsepower are used.

There is perhaps no characteristic of the gas engine more noteworthy than its high efficiency in small sizes. The automobile, aeroplane, or small motorcycle engines are almost as efficient in their consumption of fuel as the large engines of 1,000 horsepower or more.

A 50-horsepower, vertical trunk type engine will give a unit

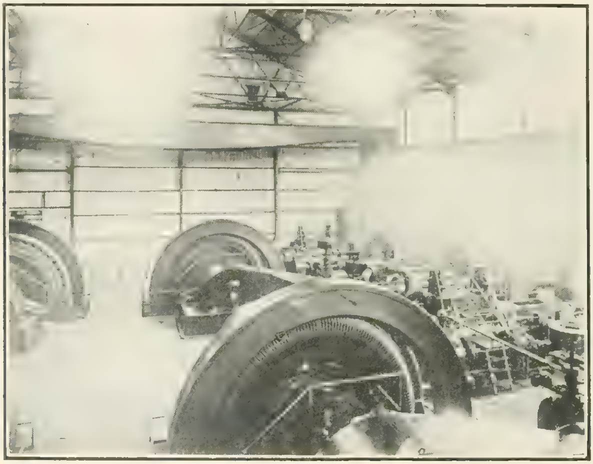

Fig. 2.

of power on less fuel than a 5,000-horsepower, double-acting gas engine.

With the aid of the stereopticon, I will now give illustrations of one large gas engine plant, and several of moderate size with brief statements of cost of operation.

Fig. 2 is of a plant installed for the Milwaukee & Northern Railroad, at Port Washington, Wis. The engines are two Allis-Chalmers, 1,000-kilowatt, twin tandem, 32x42, at 107 revolutions per minute. These engines are guaranteed to develop a maximum of 2,000 horsepower each on producer gas. The producers are Loomis-Pettibone. During the year 1909, these engines delivered 5,426,550 kilowatt hours. Although this shows but 31 per cent load factor, the cost per kilowatt hour, including interest, depreciation, maintenance, labor, fuel and miscellaneous expenses was but 1.3 cents.

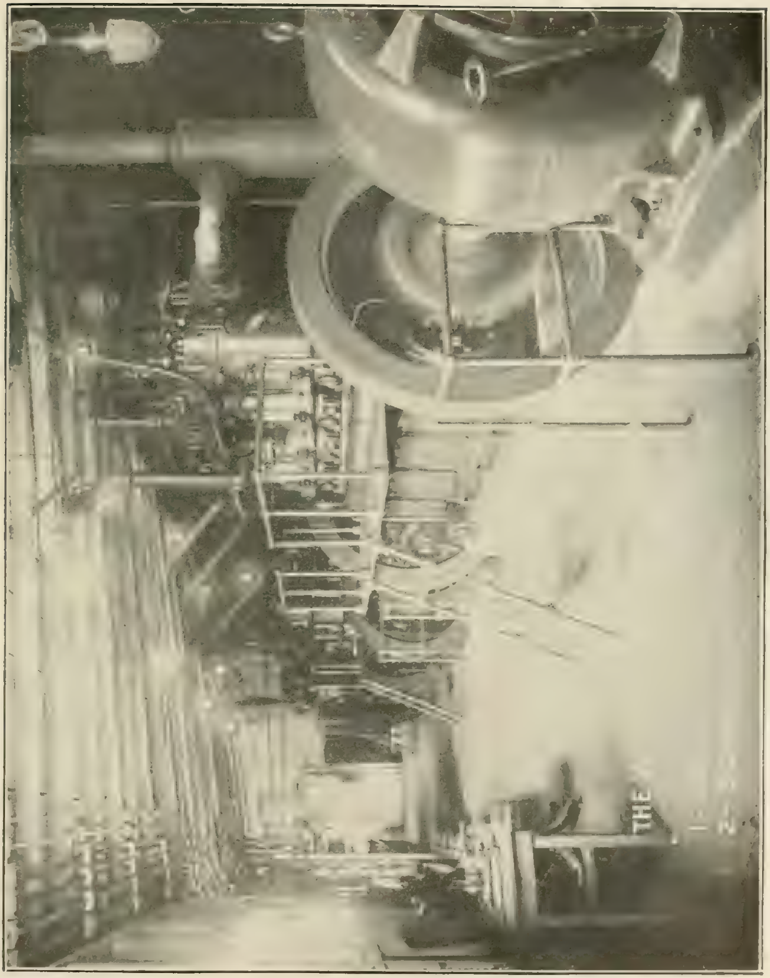

Fig. 3.

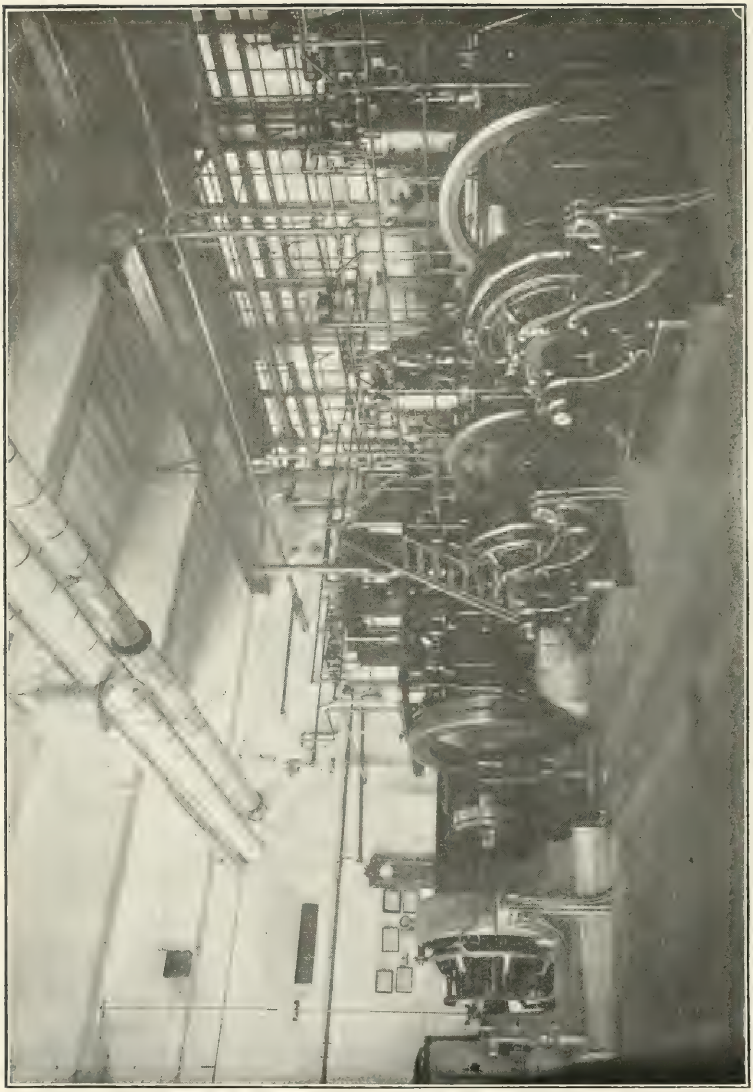

FIG. 4.

Fig. 3 is the Willard Storage Battery Co., of this city. This plant consists of two 80-horsepower twin-cylinder engines, one 135-horsepower, four-cylinder, and one 300-horsepower, four-cylinder engine. All of these engines are vertical trunk type engines, which is the design proven to be the highest in mechanical efficiency. A cross section through a single cylinder of any one of these engines may be seen in Fig. 1.

This plant operates at a very high load factor and it is quite

Fig. 5.

common for some of the engines to have operated for several weeks at full rated load without stopping. This is quite ideal for economical operation, and with an allowance of 6 per cent interest and 10 per cent depreciation, insurance, labor, water, engine room supplies, fuel (natural gas at 30 cents), and an additional charge of $25.00 rental for the engine room, this plant is producing current at less than seven-eighths of one cent per kilowatt hour.

Fig. 4 shows the plant of the E. R. Thomas Motor Car Co.,

Buffalo, N. Y. This plant consists of two twin-cylinder engines of 100 horsepower each, and one four-cylinder engine of 300 horsepower. As in the plant just described, these engines are all direct-connected to generators. This plant is supplying current at less than 1 per cent per kilowatt hour, but its load factor

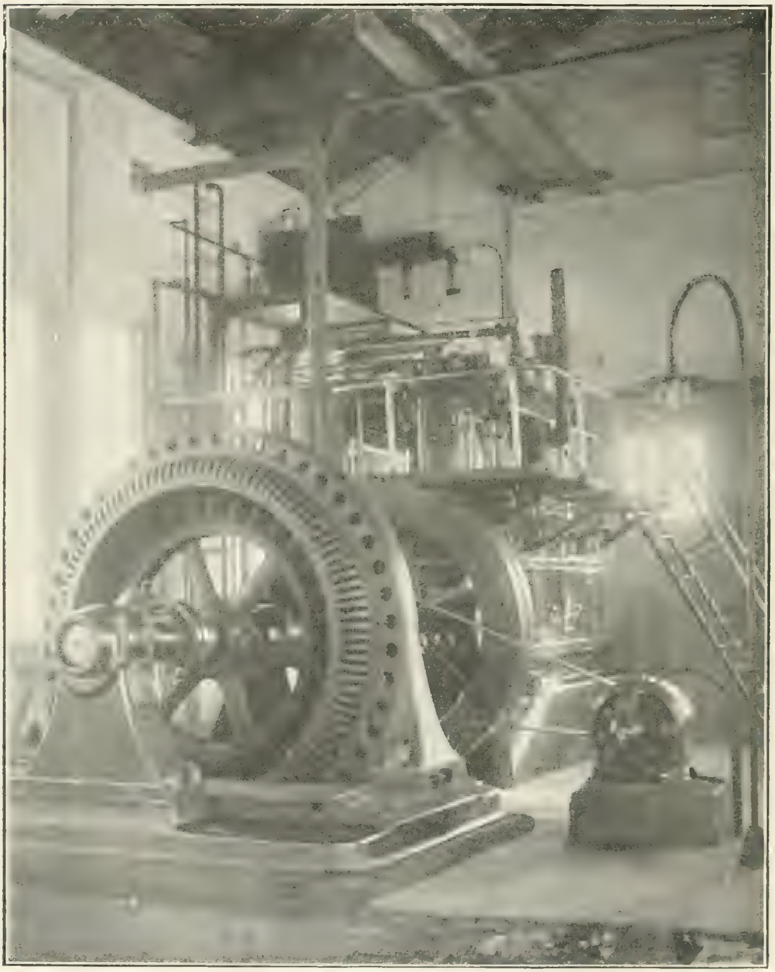

Fig. 6.

is considerably lower than the one previously described. Mr. Geo. Bowmar, chief engineer for the E. R. Thomas Motor Car Co., has equipped two of these engines with exhaust gas hot water heaters of his own design, and is affecting very great saving in his coal consumption during the winter months.

By means of this exhaust heater, he is able to deliver the

entire supply of water for his boilers at a temperature of 260 degrees Fahr.

In Fig. 5 is shown a plant installed for the New First National Bank building, of Columbus, O. This is a four-cylinder, 100-horsepower gas engine, direct-belted to a four-stage centrifugal pump, with a capacity of 700 gallons a minute against a 330-foot head. This plant replaced an electric motor-driven triplex pump for the operation of hydraulic passenger elevators. The cost of operating these elevators when electrically driven

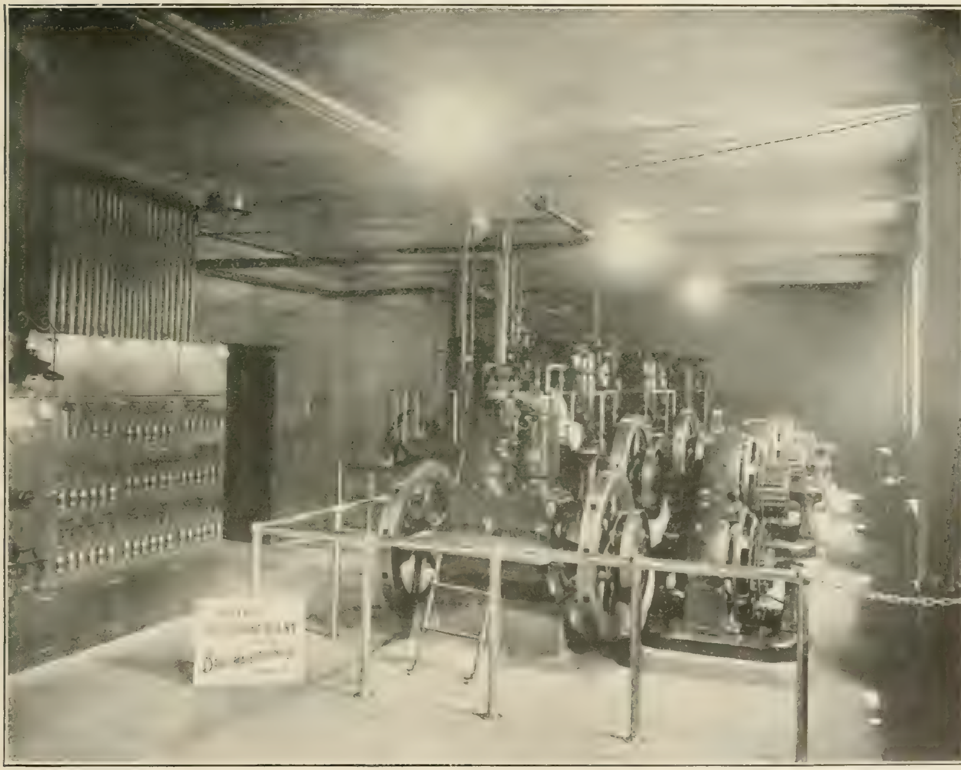

FIG. 7.

at 3 cents per kilowatt, was $11.50 per day, in spite of the fact that special controlling devices had been installed, so that an electric motor automatically stopped and started with the demand of the service.

The gas engine plant was installed under a guarantee that the fuel cost of operation would not exceed $1.50 per day. The plant has now been in operation three or four years, and the average cost has been less than $1.40, or a saving of over $10.00 per day. It might be well to call attention that in the operation

GAS ENGINE TEST
BRUCE-MACBETH ENGINE CO.,
CLEVELAND, O.

VERTICAL TYPE, FOUR-CYLINDER, 13X16, 200-B. H. P.
No. 577, Nov. 15, 1910.

Cu. Ft. Gas Per Hour by Meter.	Rev. Per Min.	Net Weight on Scales.	B.H.P.	Gas Press. Hg.	Cu. Ft. Gas Per B.H.P. Meter.	Gas Per B.H.P. Corrected.	*Effective B.T.U. Per B.H.P. at Atmos. (14.4)	B.T.U. Per B.H.P. Guarantee.
1,803	267	526	223.7	0.791	8.39	8.61	8,119.2	......
			(11.8 per cent overload.)					
1,785	268	501	213.9	0.791	8.7	8.83	8,326.7	......
			(5.2 per cent overload.)					
1,650	271	451	194.7	0.791	8.85	9.09	8,571.8	10,000
			(Full load.)					
1,560	271	348	150.2	0.791	10.38	10.66	10,052.4	11,500
			(Three-quarter load.)					
1,293	274	232	101.2	0.791	12.77	13.11	12,372.7	13,000
			(One-half load.)					

*Atmospheric pressure, 14.4 lb., assumed normal.

DATA:—Brake beam radius=100.375″=8.364′.
Brake circumference=8.364′×2×3.1416=52.573′.
Beam weight forward=210 lb.
" " back=138

$$\text{Net tare}=\frac{348}{2}=174 \text{ lb.}$$

Gas pressure at meter=10¾″, water=6.2 oz.=0.791″ hg.
Temperature gas at meter=70°.
Effective b. t. u. per cu. ft.=943.

Test run by J. B. MERIAM, Bruce Macbeth Eng. Co.

Witnessed and certified for State Institution for Feeble Minded of Western Pennsylvania, by

F. H. KINDL,
Con. Engr., Pgh., Pa.

GEO. B. HAYES,
Engr. for State.

FIG. 8a.

GAS ENGINE TEST
BRUCE-MACBETH ENGINE CO.,
CLEVELAND, O.

VERTICAL TYPE, FOUR-CYLINDER, 13X16, 200-B. H. P.
No. 578, Dec. 9, 1910.

Cu. Ft. Gas Per Hour by Meter.	Rev. Per Min.	Net Weight on Scales.	B.H.P.	Gas Press. Hg.	Cu. Ft. Gas Per B.H.P. Meter.	Gas Per B.H.P. Corrected.	Effective B.T.U. Per B.H.P. at Atmos. (14.4)	B.T.U. Per B.H.P. Guarantee.
1,845	267	520	219.1	1.7	8.42	8.91	8,407	......
			(9.5 per cent overload.)					
1,725	267	470	198	1.7	8.71	9.22	8,694	10,000
				(Full load.)				
1,470	269	345	146.5	2.0	10.03	10.72	10,815	11,500
			(Three-quarter load.)					
1,245	272	235	100.1	2.1	12.43	13.33	12,570	13,000
			(One-half load.)					
879	273	120	51.7	2.5	17.00	18.46	17,408	......
			(One-quarter load.)					

DATA:—Brake beam radius=99½″=8.29′.
Brake circumference=8.29′×2×3.1416=52.08′.
Beam weight, net tare=180 lb.
Gas pressure at meter=1.7 to 2.5 hg.
Atmospheric pressure=14.4 lb., assumed normal.
Effective b. t. u. per cu. ft. of gas=943.

N. B.:—The effective b. t. u. per cu. ft. of gas was assumed to have been determined for both tests at 11.4 lb. atmospheric pressure and 70°.

Test run by J. B. MERIAM, Bruce Macbeth Eng. Co.

Witnessed and certified for State Institution for Feeble Minded of Western Pennsylvania, by

F. H. KINDL,
Con. Engr., Pgh., Pa.

N. C. WILSON,
Con. Engr., Pgh., Pa.

GEO. B. HAYES,
Engr. for State.

FIG. 8b.

of the hydraulic elevators by centrifugal pump, it is necessary to provide in some manner for the over-heating of the pump, due to skin friction when the pump is running, but the elevators are not in operation. This has been nicely taken care of in this plant by providing the pump with a special control valve and the engine with a special control device so arranged that when

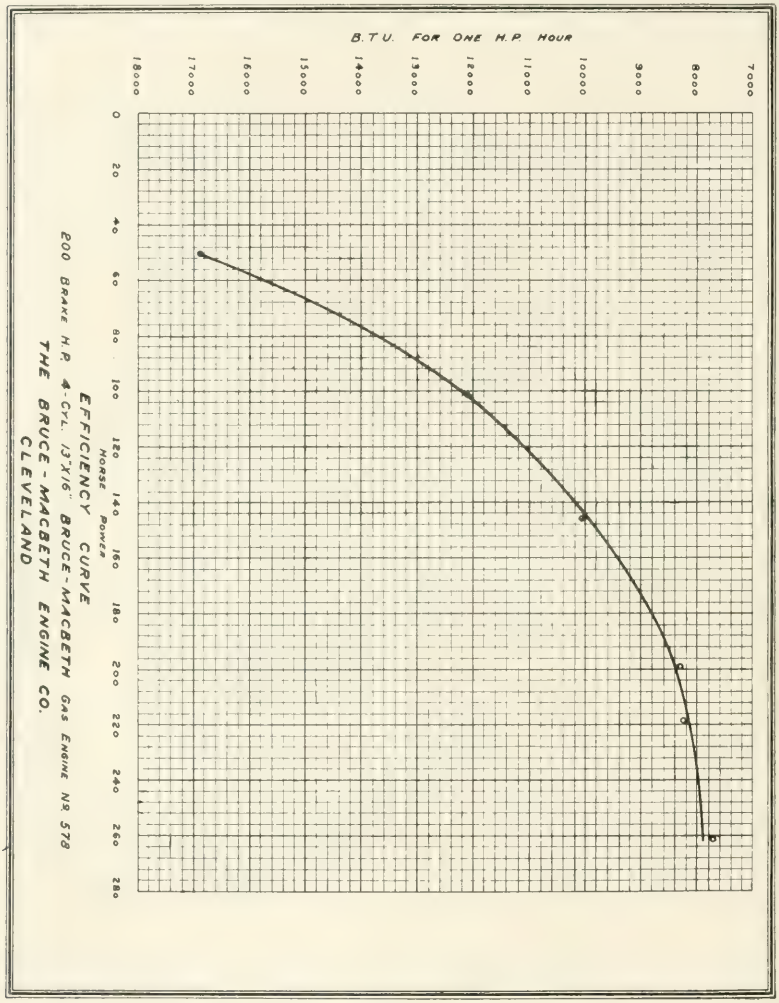

Fig. 9.

the pressure in the elevator tank reaches 145 pounds, the engine is automatically reduced so that the speed is reduced to one-half. This reduces the pressure in the pump which varies as the square of the speed to one-fourth of 145, or about 36 pounds. Under these conditions, no trouble is experienced and the plant is proving all around very satisfactory and highly economical.

Fig. 6 shows the 300-horsepower plant for street and commercial lighting for the city of Dover, O. This plant has been in operation about a year and a half, delivering alternating current at a fuel cost under normal running conditions of less than ½ cent per kilowatt hour. A second and duplicate unit is now being installed, and when completed, 24-hour service will be provided.

Fig. 7 is of a plant installed for lighting and power equipment of the county buildings at Youngstown, O. It consists of three 150-horsepower, four-cylinder units, and one 35-horsepower, twin-cylinder unit. The small unit is used for night lighting and the operation of a vacuum cleaning system.

Figs. 8a, 8b and 9 give the table and efficiency curve of test of a 13x16, four-cylinder engine, operating on natural gas. The figures are self explanatory. The results obtained by this test are believed to show about the highest efficiency in any engine using gas as a fuel.

In closing, we wish to quote from the report of the water commissioners of the city of Bradford, Penna., for the year 1910.

"The water supply this year has been good in spite of the extreme drought, which commenced June 1, and lasted until Nov. 1, and the reason for this was on account of our excellent facilities to furnish water when needed, and credit for the same must be given to the much talked of pumping plant. This plant has been completed under much adverse criticism. The plant now consists of one 135-horsepower gas engine of the Bruce-Macbeth pattern; one 2,000,000-gallon centrifugal pump and 11 driven wells, six 8-inch holes and five 10-inch holes, all of them about 120 feet deep. The plant is in first class condition and cost approximately $11,000.00. The cost to run the plant the five and one-half months this summer was $1,376.00 during which time it pumped 180,000,000 gallons; last summer we pumped 63,000,000 gallons at a cost of $1,824.13, showing that the cost to pump per 1,000,000 gallons this summer (with gas engines) was $7.66, as against (with steam) $28.94 last summer."

The report of the superintendent then goes on to say that "a very satisfactory reduction in our fire insurance rates was made by the fire insurance companies on all properties in the city" on account of the reliability of the plant.

Public Work in the City of Cleveland

The end of the year 1911 marks the completion of the usual amount of public improvements. The rapid development of the city necessitates that each year there shall be built a considerable mileage of sewers and pavements, that certain bridge improvements shall be advanced, that grade crossings shall be eliminated, and that projects in connection with the maintenance of the health of the city shall be undertaken.

About one hundred and twenty-five (125) streets have been paved, and eight (8) other streets have had their paving interfered with by the early arrival of the winter weather.

Forty-two (42) main sewer contracts have been undertaken, of which fourteen (14) are still in progress. In addition to these, some twenty-five (25) private sewers, built under the supervision of the city, have also been completed.

In connection with the much desired grade crossing improvements, the work along the line of the N. Y., C. & St. L. Ry. Co. in the eastern portion of the city, has been practically completed, so that Euclid avenue, Mayfield road, Cornell road and Adelbert road, East 105th street and Quincy avenue now have their grades separated from that of the railway tracks. In addition to these, new bridges at Cedar avenue, East Boulevard and Fairmount road have been completed, together with a foot bridge across the railroad right of way at Woodhill road. The completion of these bridges marks the ending of a million dollar undertaking of a rather complicated character, which was well executed and directed. The difficulties of caring for street and railway traffic were unusually great.

The concrete bridges used are a departure from the style of construction used in the grade elimination work in other parts of the city. The bridges present a pleasing appearance, the one at East Boulevard being a type worthy of special mention, on account of the pink granite used in the surface of the concrete.

The grade crossing work along the line of the Pennsylvania in what is known as Group 2, extending from Central avenue to East Twenty-sixth street, has been begun. The work so far has consisted mainly of driving the pile trestles between Euclid avenue and East Thirty-third street, necessary to carry the steam railway traffic temporarily at a grade above the present street level, so as to admit of construction work. As soon as the trestles are completed, it is intended to turn traffic upon the same, so that probably the grade crossings now existing between Windsor avenue and East Thirty-third street will be eliminated soon after the first of the year. The work of eliminating the Pennsylvania grade crossings between Central avenue and East Twenty-Sixth street involves the expenditure of over two and one-half million dollars.

The new tuberculosis hospital at Warrensville is under construction and is one of the much needed institutions, for which all large cities now find urgent demand.

The most important of the proposed work is probably the extension of the water works tunnel from the old water intake westerly of Cuyahoga river to a location near the new water intake, so as to provide an extra water supply in addition to that afforded by the tunnel extending from the Kirtland street pumping station. This work involves an expenditure of about one million dollars and is now being advertised for bids.

The Clark avenue viaduct is the structure for which the city council has authorized the issuance of seven hundred thousand dollars worth of bonds. The distance between the high lands on the easterly and westerly sides of Cuyahoga Valley at Clark avenue is more than a mile. The problem of designing this bridge is somewhat complicated, in that diverse interests must be considered, one being traffic which will wish to travel from the high land on one side of the river to that on the other without any reference to the necessity of access to the low land underneath. The other interest is that of the low lying lands, for which an approach is desired from the high lands on each side, as well as a crossing over or under the many railroad tracks now crossing Clark avenue, and for which a bridge is desired across Cuyahoga river to Independence road. The problem really involves a high level project and a low level project. Preliminary plans are now being made, and in connection therewith four or five different schemes are being considered.

Society Notes

MINUTES OF MEETINGS

May 9, 1911.

Regular meeting on the sixth floor of the Chamber of Commerce building, called to order by President Frazier at 8:00 P. M. Present, about 80 members and guests.

Minutes of meetings, of April 11 and 25, read and approved.

Applications for membership from the following were read and passed to letter ballot:

For active members:—

Jerome C. Alderman	Hyman H. Mandelzweig
Henry A. Baumhart	Kenneth A. Marsh
Rufus C. Beardsley	Alfred C. Nelson
Earl H. Browning	Edward G. Spitz
William W. Chace	Ernest W. Taylor
Daniel J. McCormack	

For transfer, associate to active members:—

Adolph J. Friedman   Francis Line

For associate member:—

Richard P. Cattrall, Jr.

For corresponding members:—

Charles D. Clark   Benjamin H. Whittaker

The Teller's report showed the unanimous election of the entire membership list published at the meeting, April 11, and the amendment to the constitution proposed at the same meeting, carried by a vote of 60 ayes and 11 noes.

The Nominating Committee reported that the following persons had accepted nominations as officials for the ensuing year:

E. P. Roberts, *President*	B. R. Leffler, *Director*
David Gaehr, *Vice President*	A. J. Himes, *Director*

Upon motion, duly seconded, the report of the committee was accepted and referred to letter ballot.

A communication from Mrs. A. E. Brown, acknowledging receipt of flowers sent by the Society on the day of Mr. Brown's funeral, was read.

The President announced that a committee to draft resolutions on the death of Alexander E. Brown, would be appointed in a few days.

The paper of the evening on "Storage Batteries" was prepared and read by Mr. A. B. Burk, Jr., instead of Mr. Chappelle, as announced, Mr. Chappelle being unable to be in attendance at the meeting. The paper was well received and was followed by considerable discussion and many questions, which Mr. Burk answered.

A vote of thanks was given Mr. Burk for his able paper.

Upon motion of Mr. Herman, duly seconded, the meeting recessed to May 23, 1911.

Geo. H. Tinker,
Acting Secretary.

May 23, 1911.

Adjourned meeting on the sixth floor, Chamber of Commerce building, called to order by President Frazier, at 8:00 P. M. Present, 65 members and guests.

President Frazier announced that the object of adjourning the meeting of May 9 was to allow the Membership Committee to report on their work of securing new members and publish the names to the Society, so they could be canvassed at the regular meeting in June.

The following names were read and passed to letter ballot:

For active members:—

W. D. B. Alexander	G. E. Guy
F. G. Bates	S. T. Henry, Jr.
Anton Burchard	J. B. Meriam
A. M. Clark	E. F. Mould
F. S. Coke	C. E. Pettibone
G. F. Collister	F. R. Sites
J. C. Gorton	A. S. R. Smith

For associate members:—

F. J. Dresser	L. J. Murray

For corresponding member:—

G. D. Claflin, Jr.

Mr. Frazier reported that Mr. Gaehr, the nominee for Vice President, had written a letter to the Executive Board, withdrawing his name from the ballot, and that letters had been received, signed by more than the required number of active members, placing in nomination Prof. R. H. Fernald, and Mr. F. F. Prentiss. Upon motion, duly seconded, the Secretary was instructed to substitute the names of these two gentlemen on the ballot as candidates for Vice President, in lieu of the name of Mr. Gaehr.

The President then introduced the speaker, Mr. Claiborne Pirtle, Vice President of the Electric Controller & Mfg. Co., who presented a very interesting paper on "Some Recent Improvements in Electric Motor Control", illustrated with many lantern slides.

After a few questions, which were answered by the speaker, the meeting recessed to June 6, 1911.

G. S. Black,
Acting Secretary.

June 6, 1911.

Recessed meeting called to order at 8:30 P. M. by Vice President Roberts, in the club rooms. Present, 15 members.

Vice President Roberts announced that the object of the meeting was to consider a number of applications for membership which had been received, whereupon the Secretary read the following names of applicants, all of which had been favorably considered by the Executive Board:

For active members:—

Geo. S. Case	Hans A. Hohmann
Harry O. Davidson	James F. Lincoln
Augustus M. Frink	Edward Lindmueller
Charles A. Grate	Fred W. Mettler
Samuel A. Hand	Monroe Warner

For associate members:—

Charles C. Coventry	Harry Gillett

Upon motion, duly seconded, these names were ordered prepared for letter ballot, to be canvassed at the regular meeting in June.

Adjourned.

F. W. Ballard,
Secretary.

June 13, 1911.

Thirty-First Annual Meeting and Banquet, at the Cleveland Chamber of Commerce Auditorium, called to order at 8:30 P. M. by President Frazier. Present, 121 members and guests.

Reading of minutes dispensed with.

The President called for the names of applicants for admission to membership, and the Secretary read the following names, which on motion, duly seconded, were passed to letter ballot:

For active members:—

JOHN R. CROUSE	THOMAS G. PROTHEROE
FORD DONLEY	GEORGE R. WADSWORTH
HERMAN R. NEFF	EDWARD N. WALTON

The Chairman then read the Teller's report, which showed that the entire membership ballot had been elected, and that the following officers had been elected for the coming year:

E. P. ROBERTS, *President* — R. H. FERNALD, *Vice President*

A. J. HIMES and B. R. LEFFLER, *Directors*

The Secretary also read the financial statement for the year ending May 31, 1911.

There being no further business, the program for the evening followed, after which the meeting adjourned.

F. W. BALLARD,
Secretary.

Sept. 12, 1911.

Meeting consisted of a trip to Lorain to visit the plants of the American Ship Building Co., and the National Tube Co. Present, 143 members and guests.

The party took dinner at the Hotel Lorain, and a regular business session was held, at which the Secretary read a poem, written by Mr. E. P. Roberts, entitled "Smoking Here and Hereafter".

The Teller's report was read and the entire membership ballot was declared elected. (List of names in minutes of June 13.)

The following list of applications for membership, which had been approved by the Executive Board, was then read and passed for letter ballot at the next regular meeting:

For active members:—

PAUL T. BUCKLER	EARL H. PAYNE
SAMUEL H. COX	WILLIAM E. PEASE
HARRY D. CUSHMAN	WALLACE R. PERSONS
ROBERT DEMING	CHARLES E. POPE
BERT A. HARMAN	GEORGE T. SINKS
EDWARD M. JUSTIN	JAMES G. TYLER

A vote of thanks was extended to the engineers of the National Tube Co., and also the American Ship Building Co., for their courtesy in entertaining us and showing us through their plants.

Meeting adjourned.

F. W. BALLARD,
Secretary.

Sept. 26, 1911.

Special meeting in the Chamber of Commerce hall, sixth floor, called to order by President Roberts at 8:00 P. M. Present, 122 members and guests.

The paper was presented by Mr. Paul P. Bird, of Chicago, on the subject of "Smoke Prevention", and was followed by a lively discussion of this question by both members and visitors.

Mr. Bird was extended a vote of thanks for his paper.

Adjourned.

F. W. BALLARD,
Secretary.

Oct. 10, 1911.

Regular meeting in the Chamber of Commerce Auditorium (first floor). Present, 133 members and guests.

Minutes of May 9, May 23, June 6, June 13, Sept. 12 and 26, read and approved.

The following list of applications were received from the Executive Board, and were duly passed to letter ballot:

For active members:—

ROBERT H. COWDERY
PAUL E. BAKER
CHARLES FIELD, 3D
GUSTAV A. KOHLER
WILLIAM M. KRICKBAUM
THOMAS A. LAWES
LEE H. MILLER
DALTON MOOMAW
GERALD D. MUGGLETON
RALPH D. NYE
CHAS. M. POND
HORACE P. RODGERS
HERBERT C. SNOW
WARREN D. SPENGLER
WILLIAM J. YOUNG

For associate members:—

CHRISTIAN GIRL
CARL D. PALMER

For transfer from associate to active member:—

ALBERT H. BATES

There were 64 ballots canvassed and all were in favor of the election of these men.

A letter was read from Mrs. Alice Gobeille, announcing the death of her husband, Joseph Leon Gobeille, which occurred on Sunday, Sept. 27, 1911. President Roberts stated that a committee, composed of Mr. Ambrose Swasey, Chairman; Mr. F. C. Osborn, and Mr. Augustus Mordecai, had already been appointed to draft resolutions in regard to the death of Mr. Gobeille.

A letter from Mr. Frank C. Osborn was read, announcing the gift of two framed views of the important hydro-electric engineering work at Keokuk, Ia., by Mr. Louis N. Weber, of the firm of Weber, Lind & Hall. The letter contained the following resolution:

"It is hereby resolved that the Cleveland Engineering Society expresses to Mr. Weber its appreciation of his gift, and tenders him a vote of thanks for his kind thoughtfulness and generosity."

"I move the adoption of the resolution."

This resolution was seconded and carried, whereupon the program of the evening was taken up. The program consisted of a paper by Mr. E. P. Roberts, on "Profitable Sharing vs. Profit Sharing". This very able paper came in for a general discussion, in which the following persons participated: Messrs. Sturges, Stone, Ranney, A. B. Roberts, Beahan, Himes, Hoffmann and E. P. Roberts.

After the discussion, the meeting adjourned.

F. W. BALLARD,
Secretary.

Oct. 24, 1911.

Special meeting in the Chamber of Commerce Hall (sixth floor), called to order by Vice President Fernald at 7:45 P. M. Present, about 100 members and guests.

There being no business to come before the meeting, the Vice President introduced the speaker, Mr. Chas. S. Gingrich, of the Cincinnati Milling Machine Co., Cincinnati, O., who gave an interesting and instructive talk, illustrated with many lantern slides, on "Modern Machine Shop Milling Processes". At the close of his talk, Mr. Gingrich was asked a number of questions concerning the operation of milling machines, which he answered at length.

A vote of thanks was tendered the speaker.

Adjourned.

F. W. Ballard,
Secretary.

Attention is called to the postal cards recently sent to all members, requesting information as to membership in other technical and scientific societies. Any who have not returned the cards are urged to do so at once. Do not forget to sign them. When the information has been compiled, members will be asked to assist in furthering the growth of the library.

The Need of Engineering Reference Libraries.

The following quotations are taken from an editorial with the above title in *Engineering News* of Nov. 23, 1911:

"Every engineer in the United States ought to be able to reach a good engineering reference library, at least without traveling beyond the borders of his own state.

"It is worth particular emphasis also that if such engineering reference libraries * * * are to reach their highest usefulness to the profession, they must be conducted under engineering direction."

The entire article is well worth reading and the above paragraphs have been quoted because they echo the thought that has been in the minds of the library management and which has been referred to at intervals in these columns.

Cleveland is an engineering city and its engineers should have at their command a good engineering reference library. The Cleveland Engineering Society is the logical custodian and manager of such a library. Its administration is one of the important activities in which the Society can engage to the benefit of the city of Cleveland and the profession.

No active work towards raising an endowment fund for the library has yet been inaugurated, but it is believed that the proper time to start such a movement is close at hand.

Several new exchanges will be found on the reading room tables.

For those who read French, *Le Cement,* published in Paris, will be found to contain some interesting matter.

This department is for the use of members desiring positions or requiring engineering services; it is under the personal direction of the secretary, who is anxious to increase its value to the members. Therefore, if you are in need of engineering help, or desire to secure a position, do not hesitate to call on the department for assistance.

All information is handled confidentially.

POSITIONS VACANT.

No. 4V. Machine tool salesman. Prefer a man with technical education and training. Considerable commercial experience required as well as familiarity with various lines of machine tools.

No. 5V. Mechanical engineer. Technical graduate with one or two years' experience preferred.

No. 6V. Steam engineer. Principally outside work; large manufacturing plant in city. Should have two or three years' experience.

MEN AVAILABLE

No. 10A. American; 33 years of age; graduate of Columbia School of Mines, also three years at Case School of Applied Science; desires position as mine superintendent or engineer. Experienced in mining work as draftsman, surveyor, engineer and superintendent.

No. 11A. American; 29 years of age; graduate of University of Michigan, Engineering Department; experience covers construction work along mechanical lines. Desires position as mechanical draftsman, designer or as structural man.

No. 12A. American, experienced civil engineer desires either inside or outside position. Has spent several years in South America in charge of work there. Additional information concerning this man will be secured for anyone interested.

No. 13A. American; 28 years of age; experienced along civil and mining lines, particularly mine and field surveying; also superintendent and resident engineer in charge of coal handling equipment. Also some experience in railroad surveying and construction work.

Vol. IV No. 3

JOURNAL

OF

The Cleveland Engineering Society

Published Quarterly by the Society

March, 1912

Chamber of Commerce Bldg.
Cleveland, Ohio

CONTENTS

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Modern Machine Shop Milling Processes

By Chas. S. Gingrich.

This paper will be confined to milling processes as applied to the column-and-knee type of machine. That is the type of machine that probably comes to the mind first when a milling machine is mentioned; at least it is safe to say, that it is the type of machine in most general use and is adapted to the greatest variety of work.

By way of illustration, there will be shown several examples of the latest models of column-and-knee type millers.

Fig. 1 shows the usual form of cone-driven machines. They are made both plain and universal in the same general design.

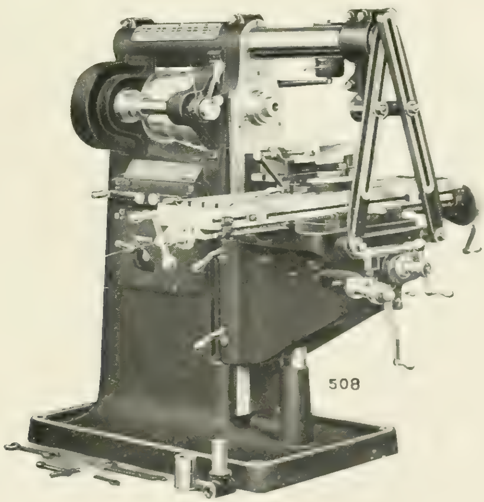

Fig. 1

Fig. 2 shows the plain machine of the single-pulley type, which we call our high power miller.

Fig. 3 shows the vertical machine of the same design.

Modern milling practice on this type of machine, as it has been developed in the manufacture of duplicate parts in reasonably large quantities, is based on the principle, that in order to get the greatest possible production, the machine must be so jigged up, and so designed that it may be continuously busy all day long. This paper will describe and illustrate three systems of continuous milling—circular or rotary milling; reciprocal milling, and gang milling.

The most nearly ideal example of continuous milling is the

rotary milling process shown in Fig. 4. The machine is a vertical miller using a rotary table, having mounted on it a fixture in which can be held a number of pieces, each one independent of the others. The machine can be speeded so that the operator will have just time enough to remove the finished pieces and replace them with rough ones. For the quick operator the machine can be speeded faster than for the slow one, but when the speed has been set for the man, he must work up to the machine, or there will be blank spaces passing under the cutter. In this particular case the pieces are about 3 x 4½ inches, ⅛-inch metal is removed, and they pass under the cutter at a rate that enables a man to turn out about 220 per hour. Of course, doing the work at that rate requires means of bringing to the operator

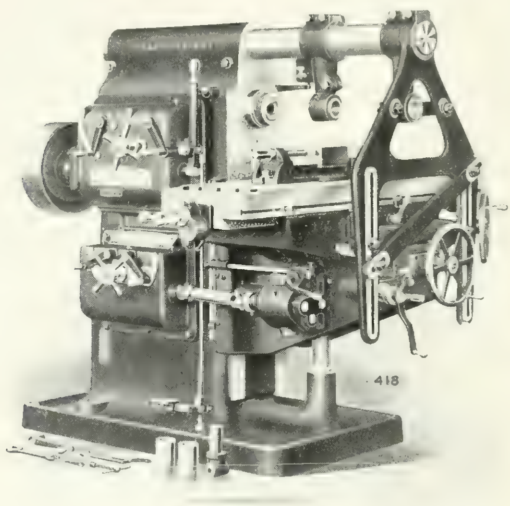

Fig. 2.

the rough castings, and getting away from him the finished ones.

This method is applicable only to pieces that can be finished at a single traverse of the cutter, in other words, pieces that must have a flat surface but do not require a high grade of finish. The success of this method will depend largely upon the ingenuity of the jig designer. The jig shown here is a simple one. There is a three-point bearing under the piece, a set of pointed set-screws grip the piece at its inner end, and it is clamped by a movable jaw, somewhat similar to the jaw of a vise, also provided with a pair of pointed screws. The clamping screw is so arranged that, assuming the piece is in place, a half turn releases it, the jaw can then be pulled straight back and the piece removed. The operator then puts the next piece in, pushes the jaw up and gives the screw a half turn, which securely clamps the piece.

Fig. 5 illustrates the second system — reciprocal milling. Here we use two fixtures, each one holding a piece of work. In this particular case the machine was arranged with an automatic trip, causing the table to feed backward and forward continuously, similar to the reciprocating motion of a manufacturing grinder.

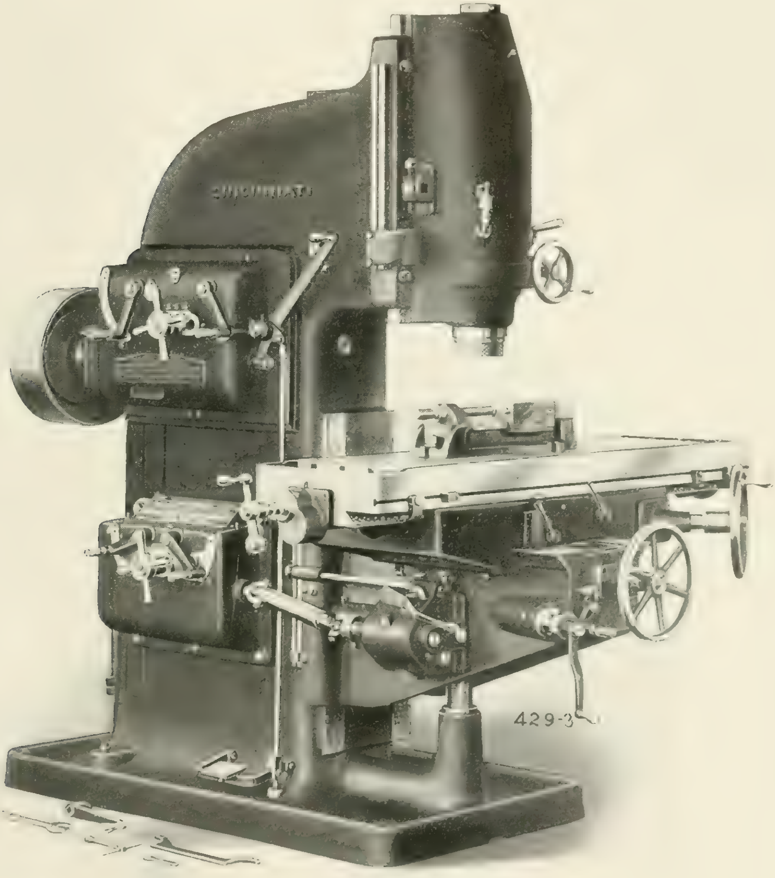

Fig. 3.

The cutter is 7½ inches diameter, runs 56 revolutions per minute, surface 6 inches x 7 inches, cut 1/16 inch to 3/32 inch deep, feed 12½ inches per minute. Total time for the two cuts and chucking each piece 1.6 minutes. All the operator had to do was to replace the piece in one fixture while the machine was milling the other. Assuming that we start with the cutter between the pieces,

then feed the table to the left for the roughing cut, reverse, and the return travel takes a finishing cut. In the meantime the operator has removed the piece and chucked a rough one in the other jig before the cutter reaches it. This process is preferred on all work that requires both a roughing and finishing cut. The return cut is sufficient to give a satisfactory finish on a large amount of work. It is just a "cleaning up" cut, so to speak.

Fig. 6 is another example of the same class of milling. These are larger pieces, and in this case the machine is not arranged with the automatic reverse. It is a standard machine, but the same principle applies. The forward roughing cut on this piece is at a feed of 7¾ inches per minute, and the return cut is taken at a feed of 20 inches per minute. That brings the pieces

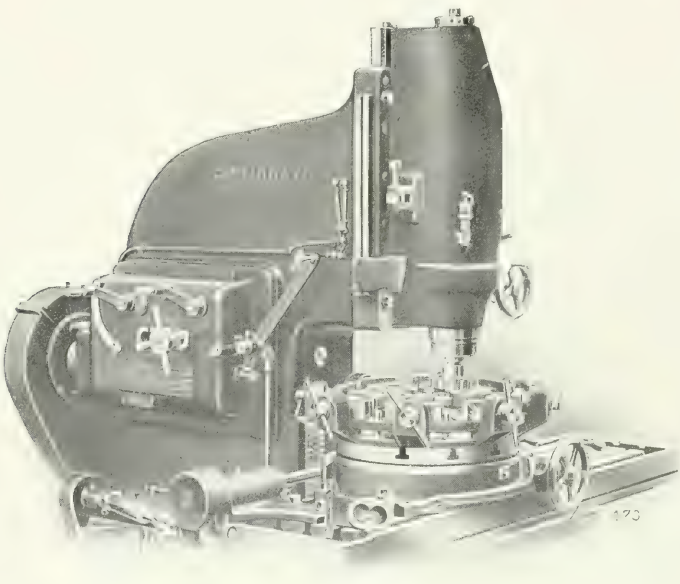

FIG. 4.

flat and with a fair degree of finish. In this particular case it happens that another final finishing cut is necessary. The milling here is exceedingly heavy, as will be apparent from the appearance of the chips and the nature of the piece. The cut is about 3/16 inch deep.

Fig. 7 is a piece of aluminum work on which the same principle applies. This work is fed under the cutter for roughing at 7¾ inches per minute, and reverses back for finishing at 20 inches per minute. In this case the operator stands behind the machine where he can control both the feed operating levers and the feed change levers. Fig. 8 illustrates the position, although this happens to show a different machine and a different piece of work. The right hand controls the table feed forward and back.

and with the left the feed change levers are operated. The illustration suggests the advantage of this method of control on a variety of end milling or face milling on horizontal machines, and it also suggests a wide application to tool room work, jig making, etc.

Fig. 9 illustrates the third system — gang-milling. Here again we approximate continuous milling by a proper arrangement of the machine and the fixture. The pieces are clamped independently, and as the cutter traverses them, the operator removes the pieces behind the cutter. When it has passed over the last one, there is a short interval of lost time while he lowers the table, returns and readjusts it. He then removes the last

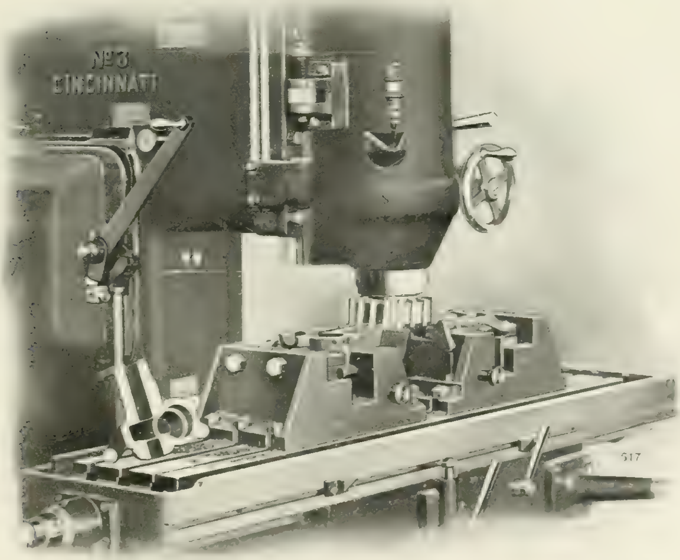

Fig. 5.

piece while the machine is milling the first one, and then he begins replacing pieces behind the cutter again. This is not the ideal continuous milling process, because of the time lost returning and readjusting the table. But this loss is small compared with the time lost by the older practice of stringing a row of pieces while the machine is stopped, and then having the operator idle while the machine is working, and so on, the operator and the machine being alternately idle.

Another modification of string jig work, particularly applicable to small work, is the loading fixture, a simple form of which consists of a clamping device fastened to the table of the machine; and two holding fixtures in which a string of pieces can be

clamped at one time. Assuming one of the holding fixtures is in place on the machine and the pieces which it contains are being milled—the operator will be busy removing pieces from the other

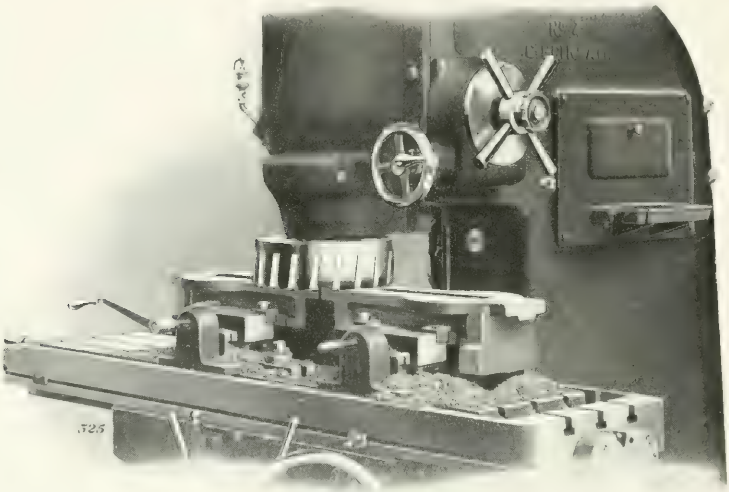

Fig. 6.

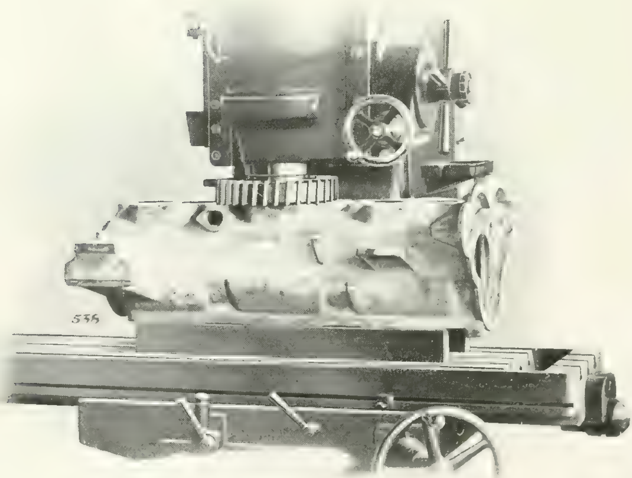

Fig. 7.

fixture and reloading it. When the pieces on the machine are finished, he releases the clamps, removes the holding fixture with its pieces and clamps the other holding fixture into place. The

lost time interval then is only that time required for removing the one holding fixture and putting the other in place; a very small loss when compared with the time that it would take to stop the machine and remove each individual piece of work and chuck another in its place.

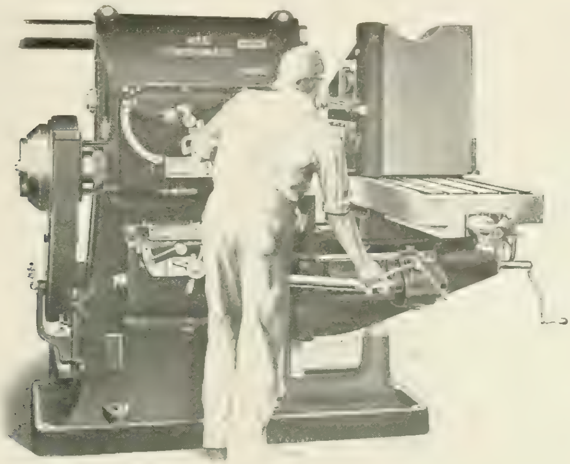

FIG. 8.

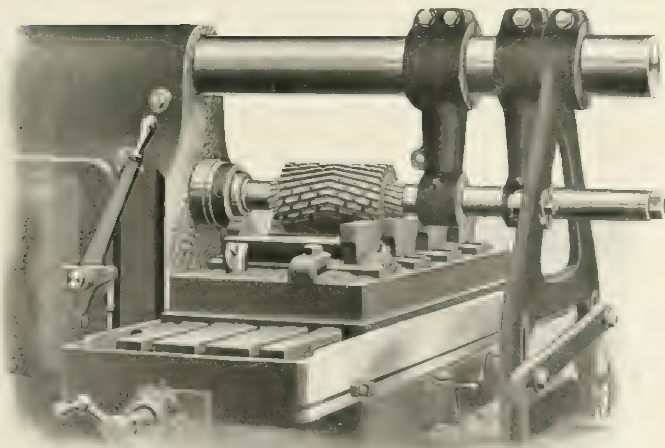

FIG. 9.

Now, it must be admitted that not all milling is manufacturing. The toolmaker also uses milling machines, and they must be built sufficiently accurate to enable him to make jigs and tools to the degree of precision which the shops require.

Fig. 10 illustrates tool room work. It shows a drill jig that requires considerable accuracy. Some of the holes are at an angle

with the radius, others are radial, and others are spaced lengthwise of the jig, but they are not all in a line, as you will see by the picture. The lengthwise spacing is checked with a micrometer in the usual way, but for the accuracy of the radial relation of

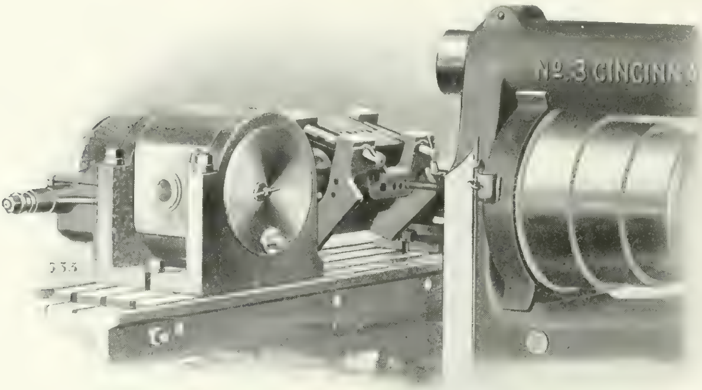

Fig. 10.

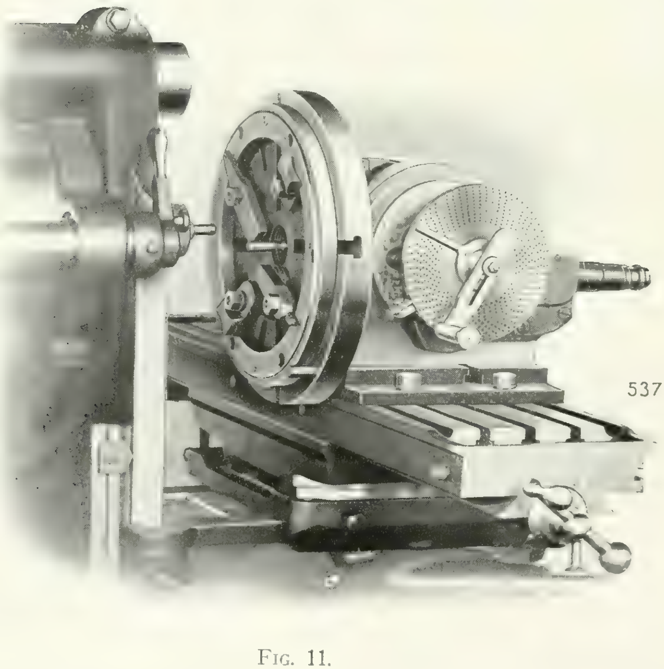

Fig. 11.

the holes with each other we must depend entirely on the accuracy of the index head. Of course, we all know that when drilling holes in a casting, the drill is likely to creep to one side. Work like this, therefore, requires infinite care on the part of the oper-

ator, in order that he may do his work as accurately as the machine will permit. For that reason the hole must first be drilled small and then brought to size with a boring tool so as to avoid all inaccuracy due to the creeping of the drill. On this piece of work, which, by the way, happens to be a jig that was taken from a lot of finished work in a tool room, the lengthwise accuracy is within 0.0005 inch, and the circumferential accuracy inside of 0.1 degree, or about 0.0006 inch on a 7-inch diameter circle.

Fig. 11 is another similar example. The holes are 1 inch diameter, drilled on a circle 14½ inches in diameter. The radial distance is obtained by touching the center plug shown, adjusting by means of the lead screw and dial, drilling the holes, checking with the micrometer, and then finally finishing to size with a

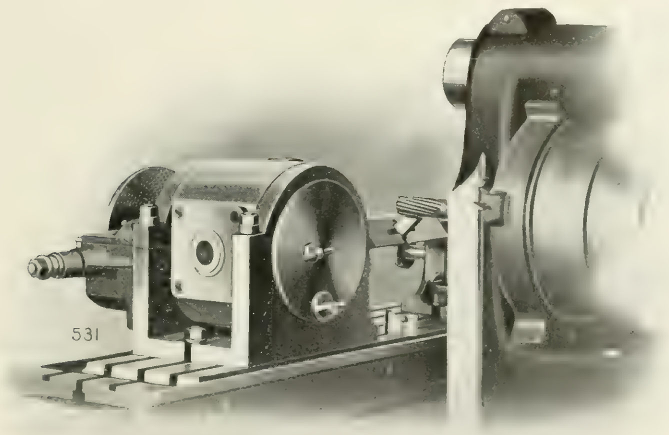

Fig. 12.

boring bar as in the previous case. The radial accuracy checked to within 0.0002 inch, and the spacing within 0.00075 inch.

It is necessary to repeat again, that on such work the operator must be a skilled and careful man, or he cannot get good results, no matter how accurate the machine is.

Fig. 12 is another tool room operation of a slightly different kind. The important thing is, that the angular face and the short side be accurate in relation to each other. The piece is mounted in a small holding fixture between centers. The short side is milled with the peripheral teeth of the cutter, and then it is revolved by means of the index head to the proper angle and the angular face is milled. The latter is the operation shown. The angle is accurate within 0.05 degree, or approximately 0.00025 inch on a 4-inch diameter circle.

One of the greatest handicaps that the milling machine has had, is improper tooling and improper cutters.

It is believed that the design of the column and knee type machines has been developed to a point where their limit of cutting capacity is reached. If this is carried too far, the machines will become clumsy and thus lose one of their most valuable features, which is handiness. As they are made now, they have a capacity far beyond the cutters found in stock. The manufacturers are, therefore, looking to the development of better cutters as a means of using their full capacity and perhaps of increasing the capacity and usefulness of these machines. It will be shown what has been accomplished through experience and experiments extending over a number of years, and a final careful series of tests and investigations, during the past three years on the part of the engineering department of the Cincinnati Milling Machine Co. A quite thorough discussion of these investigations is given

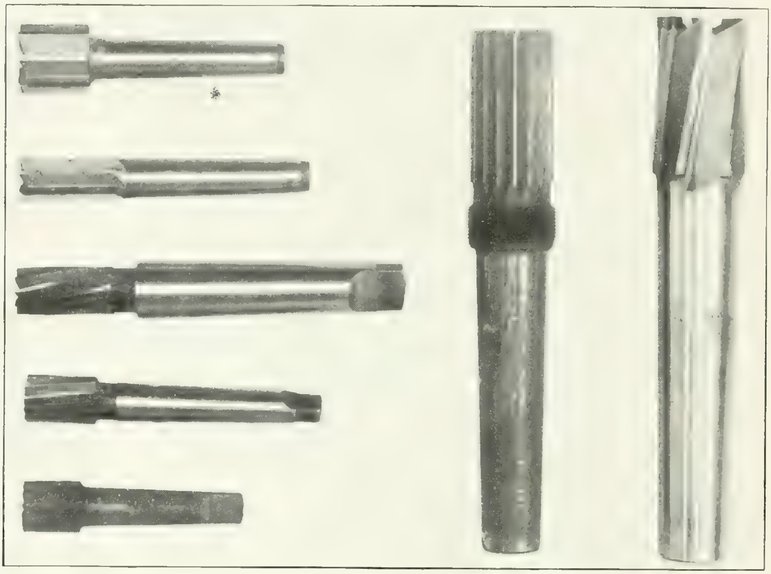

Fig. 13.

in a paper presented at the May, 1911, meeting of the American Society of Mechanical Engineers, by the chief engineer of the company, Mr. A. L. DeLeeuw, under whose supervision the final work was carried on.

It was learned long ago that on certain work a cutter with only a few teeth would give good results, whereas the older form of cutter would be a complete failure. It is probable that others have had the same experience. Through knowledge gained from isolated cases the development of a complete line of spiral mills, side mills, end mills and face mills in the most generally used sizes, was worked out. Some illustrations will be shown, contrasting the new cutters with cutters of the same style and size as found in general use.

Fig. 13 shows some end mills. The contrast is so clear that

comment is unnecessary. The large end mill at the right is $1\frac{1}{2}$ inches diameter and has six teeth. There are in use many 1-inch end mills with only four teeth.

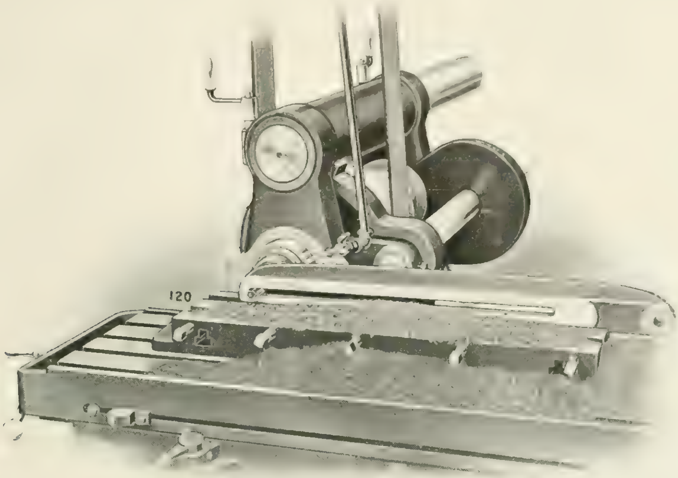

Fig. 14.

Fig. 14 shows a machine milling slots ¾ inch wide into bars 1 inch thick. The milling is done with a ¾-inch end mill having only three teeth. Work has been done in this way for

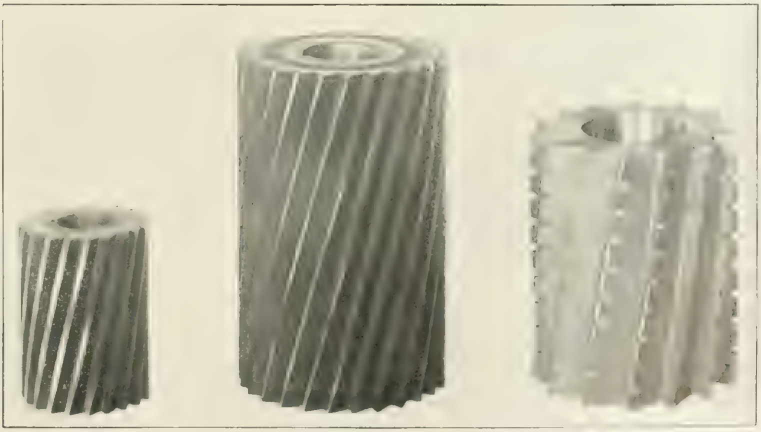

Fig. 15.

many years. It never could have been done with a standard mill, but it was successful with a five-toothed mill. Later on it was found possible to do better with a four-toothed mill. The

established feed rate then was 3⅝ inches per minute. Now the feed rate is 4¾ inches with a three-toothed mill.

Fig. 15 shows some spiral mills. It is found that mills with the teeth spaced as much as 1¼ inches apart like the one at the right will take roughing cuts that are not possible with the older style of cutters, and they are also used for finishing. It was once considered that a comparatively coarse-toothed mill, with nicked teeth, was a good thing for roughing, but for finishing, a mill like the middle one was needed. But there is no good reason for this practice. An analysis of the action of cutters shows that the mark produced by a spiral mill is a *revolution* mark, not a tooth mark. A high number of teeth, therefore, can have very little bearing on the size of the revolution mark. It does, how-

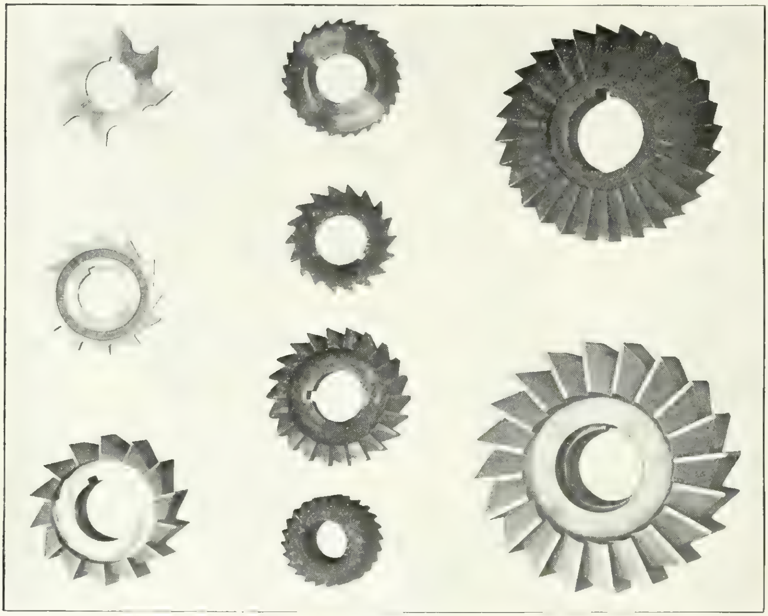

Fig. 16.

ever, affect the result in another way. The cutting face of such a cutter is nearly in a vertical position, perpendicular to the work, when it enters. It must be admitted that this is exceedingly disadvantageous, because it is difficult for the tooth in this position to enter the work and get under the chip that is to be formed. The tendency, therefore, is for the tooth to slide over the work until the pressure becomes sufficient to force it in. It can readily be seen that in a cutter, having many teeth, the chip per tooth, is correspondingly smaller, and this tendency is therefore, to the same extent, greater than in a cutter having, let us say, half as many teeth. This sliding over effect invariably gives the impression that the material being milled is exceedingly hard, and it is therefore frequently said that such results cannot be obtained on certain work. But samples from many sources have

been milled and in every case the material was easily machined, the user's whole difficulty having been a cutter action like that just described, in which the cutter chattered, leading to the belief that the limit of cut had been reached, and the "sliding over" effect produced a glazed surface, making the material appear intensely hard. There has been some investigation along this line, and it is found that using one of the older cutters on an ordinary piece of cast iron, using a speed and feed that seems proper in the light of our present knowledge of milling, exactly this effect is produced, and then, by changing to one of the new cutters, the feed can be greatly increased without increasing the amount of power consumed; the chattering effect does not exist; the glazing does not appear; the machine does not show any of the former signs of distress, and the chips come off in a manner that indicates to the observer the softest kind of iron!

Fig. 16 shows this same principle applied to saws and side

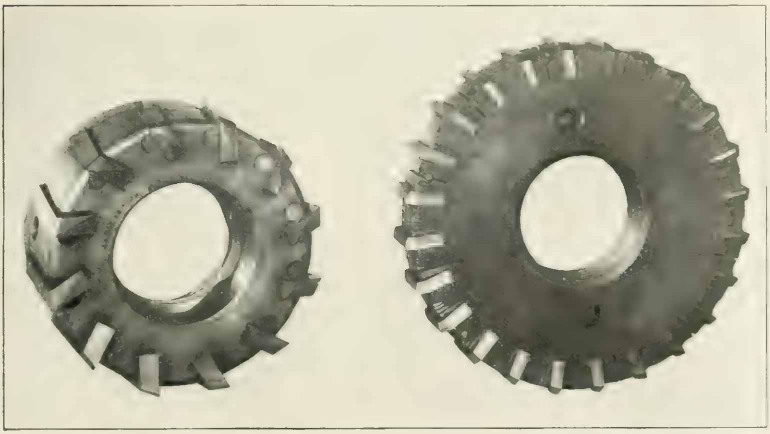

FIG. 17.

mills. The small saw at the upper left is of the same diameter as the one below it. It can take cuts that the other cannot approach. The one with 12 teeth does not have room enough between the teeth to accommodate the chips produced by a fast cut. The cutter therefore breaks, not because of the strain caused by producing the chip, but because of the pressure resulting from the crowding of the chips in the space between the teeth. The one with eight teeth has more room and the teeth are also actually stronger.

Fig. 17 shows some face mills. The one on the left is a new high power mill. The teeth are far apart and they have *rake both ways.* The older form of mill, which had rake in only one direction, by setting the blades at an angle with the axis of the bore, was based on an erroneous theory. If the cutting were done entirely by the face edge of the teeth, this would be all right, but the actual removal of metal is done by the peripheral teeth. Proper rake must therefore be obtained by setting the

blades at an angle with the radius. In grinding these, the corner should be kept small, not over ⅛ inch radius. If a large corner is used, it is obvious the rake angle is modified and may seriously affect the successful working of the cutter.

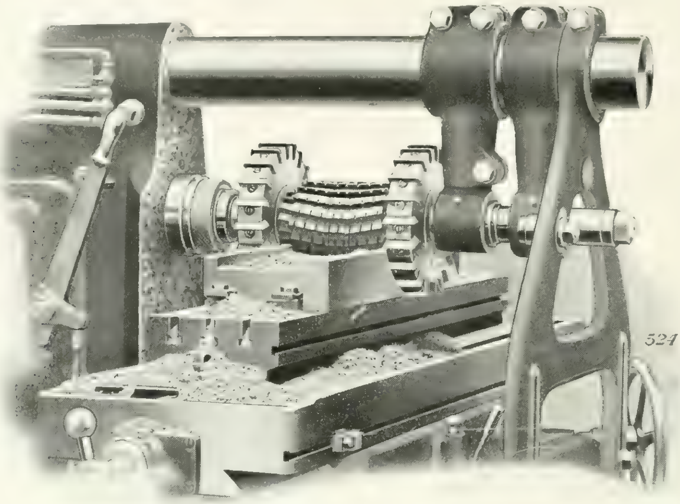

FIG. 18.

The next two pictures illustrate some of these things. The gang in Fig. 18 is made up of a pair of side mills, a large interlocked central cutter, and two smaller ones, only one of which can be seen, and mills the seven surfaces of these pieces at one

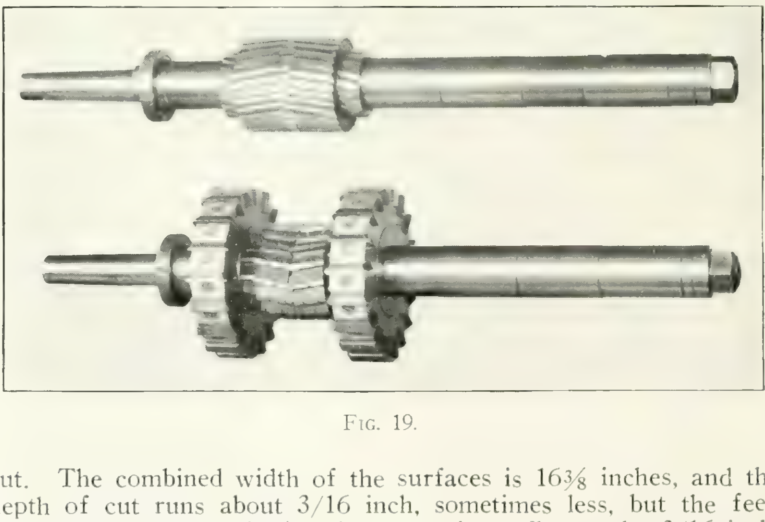

FIG. 19.

cut. The combined width of the surfaces is 16⅜ inches, and the depth of cut runs about 3/16 inch, sometimes less, but the feed rate must be set for the heaviest cut taken off, namely, 3/16 inch. The length of each piece milled is 8¼ inches. The largest cutter

is $10\frac{1}{2}$ inches in diameter. The feed is 6 3/10 inches a minute, removing 19 cubic inches of metal. These figures are emphasized to illustrate the advantage of this wide spaced gang as compared with the sort of gang formerly used.

Fig. 19 shows the gang used in the preceding picture, and also the former gang with the side cutters taken off. This older gang was used one year, and then had to be thrown away, because it was completely worn out. The new gang, when photographed, had been in use two and a half years, is still practically a new gang, and has been doing its work at a feed twice as fast as the old gang ever could do it. The old one, when milling a lot of 125 pieces, which is the quantity in which they are made, would have to be sharpened at least once, sometimes twice, before the 125 were done. The new gang mills 125 without stopping to

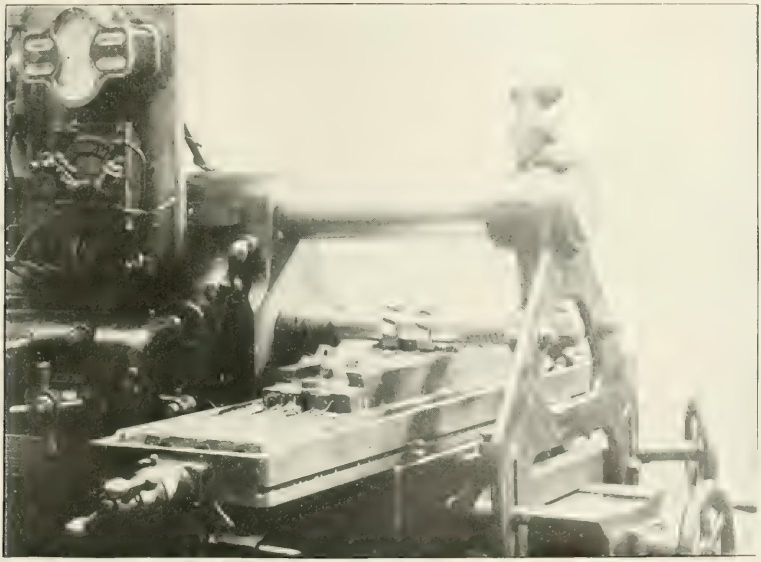

Fig. 20.

sharpen, and without slowing down the feed rate. This illustrates the fact that this new kind of cutter lasts longer, requires less time for sharpening, and will produce a great deal more work; in other words, gets more work out of the milling machines. This statement, of course, refers to machines of recent design. The older ones are not capable of working up to anywhere near the capacity of these new cutters.

Fig. 20 shows some of these cutters milling steel, the width of the surface is about an inch. It is a bar $1\frac{7}{8}$ inches in diameter. The cut is about 3/16 inch deep. Two of them are milled side by side. The cutters are $3\frac{1}{2}$ inches diameter. The teeth are spaced very wide. The pieces are fed through at a table travel of 16 inches per minute, and a very satisfactory surface is produced. You can see from the chips that they go through fast.

This cutter development is not yet completed and probably never will be completed, because as the process of milling develops further improvements in cutters will follow.

It might be added in closing, that the development has already gone further than these pictures indicate. Spiral mills with teeth spaced even farther apart, are in use. A spiral angle of about 30 degrees is being used with advantage. These cutters do not cost more to make than the old style; they cost less to maintain, and they last longer. They also do much faster work on machines that have the strength to stand up under the service.

Now, some of these statements may seem extravagant, but every example shown was taken from practice. Not one was set up as an experiment, but all were selected from work regularly in course of manufacture.

Replying to questions which have been asked, I am not prepared to state a fixed rule for determining how many teeth to put in a cutter. The investigations are not yet finished. But so much has already been accomplished that it seemed time to tell about it, although there is more yet to be done.

It has already been said that on some special operations ¾-inch end mills with only three teeth in them are now in use. The only thought followed in making these cutters with three teeth was, that they would be better than with four. When confronted with the question whether to put 12 teeth or 22 teeth into a cutter, I would certainly feel nearer right in deciding on the smaller rather than the larger number. Some of the reasons why the smaller number is preferable to a large number of closely spaced teeth, may be described as follows: In the first place, each tooth must be given a chance to produce a chip. One way to accomplish it is by putting fewer teeth in the cutter. As an example of the ordinary cutter taking a finishing cut, suppose a cutter 3½ inches in diameter with 20 teeth, feeding 0.020 inch to a revolution, taking a finishing 0.010 inch deep, and assuming that it is practical to get a cutter to revolve dead true, then in this hypothetical case each tooth is taking off a little wedge that is 0.001 inch thick at the large end and about 0.020 inch long. Knowing that cutters never will run dead true, it is evident that some teeth have no chance at all, others will ride over the work, and only the high ones will do any cutting. Obviously, a cutter with half as many teeth gives each tooth a better chance and thereby reduces the "sliding over" effect; reduces the tendency to chatter; prevents rapid dulling, and avoids much of the heating that results from the "sliding over" of the fine tooth cutter.

In regard to lubrication: Nearly all of the examples shown were cast iron work. Some were on steel, some aluminum. On these there was provision for copious lubrication. A milling machine should be provided with a pump that can deliver a sufficiently strong stream of lubricant to thoroughly wash the chips off as fast as they are formed. A good example of the necessity of this is milling solid ends of engine connecting rods. One of these was brought to my attention only a few days ago. It was a forging 3¾ inches thick. A square hole had to be cut in the end to receive the brasses. Those of you who are familiar with

engine building know that the usual way is to drill around the periphery of the hole, then knock the core out and slot the hole to size. With a properly designed cutter and a milling machine that can do it, by which is meant one that is not only strong enough, but one that has the conveniences to enable the operator to properly handle it, that job can be done by simply drilling one hole in one corner, feeding the cutter through, and then feeding around the periphery of the hole, dropping cut the core, and then going around the second time to bring it to size. This requires a machine on which it is possible for the operator to stand where he can at all times see the cutter, and, by means of his levers, make the four changes in direction without stopping. It also requires a proper cutter. In the present case the cutter was 1¼ inches diameter, had four teeth at about a 30-degree angle. The outer end of the cutter was provided with a substantial bearing. The first cut through the solid metal was taken at a feed of ½ inch per minute. A powerful stream of oil was delivered between the teeth of the cutter to drive the chips out; otherwise such work could not be done at all. This is mentioned not only as a remarkable job, but because it is prompted by this question of lubrication and the necessity for it. It is probable that the time is not far off when a fluid of some kind will be used to wash the chips away when milling cast iron. Compressed air is used a great deal now, but compressed air is very objectionable, because it blows the dust all over the shop.

When increasing the feed on a milling job, assuming a spiral mill, it is invariably a first cut or roughing cut. The feed rate on finishing cuts is not up to the cutter or the machine, but is determined entirely by the grade of finish required, bearing in mind that a revolution mark cannot be avoided. The rate of table travel per revolution must be determined by the distance it is permissible for the revolution marks to be apart.

As to providing rake for all materials. On aluminum no rake should be used. On steel, rake is desirable, also on cast iron. On the other hand, with copper, such as is used in buss bars and other parts of electrical apparatus, negative rake is absolutely necessary.

A good rule to bear in mind is that wherever a single point tool can be used continuously in the metal, as on an ordinary boring mill job, it will not pay to mill it. But if only a part of the circumference is to be finished, so that a boring tool will be cutting wind part of the time, then it will pay to mill. There are some exceptions, as for instance, in the case of eccentric rod straps and similar parts that have an irregular surface which must be made to gauge and interchangeable. Such work can often be milled with a gang quicker and better than it can be done on a machine using a single point tool.

It is not hard to keep the cutter cool when doing continuous milling. If the cutter is properly constructed, it won't get hot. Cutters get hot, not from cutting off metal, but from rubbing over the metal. Many jobs get very hot. On one case, a machine capable of taking 15 H. P. cuts, was doing about a 6 H. P. job in cast iron, and after working about three-quarters of a day, got

so hot all over that one could hardly bear his hand on it. The machine was motor-driven, and had an ammeter on it. It was stopped, the work was taken out, and the machine was run idle to determine whether there were any injured bearings which would show up in an excessive idle load. The readings of the ammeter showed normal conditions. Further examination showed all bearings in good shape. The heating was all induced heat coming from the improperly constructed cutters. A new gang was made up in accordance with the later ideas, and with it the job was done a little over twice as fast without the slightest sign of heat, because the new gang removed the metal freely and did not rub or slide over the work and produce tremendous heat by friction.

Generally speaking, the cut should always be against the cutter, not with the cutter. The whole action is more satisfactory. For instance, when taking a roughing cut in cast iron, if the feed is against the cutter it gets under the scale. If you feed with the cutter, the cutter is always entering through the scale, which is bad for the cutter. There are exceptions. In the construction of these machines there are some bars 24 to 30 inches long, from 1½ to 3 inches wide, of cast iron. It is desired to take a roughing cut from them as fast as possible. They are placed on a horizontal machine, with a spiral mill, and fed both ways as fast one way as the other, sometimes as much as 36 inches per minute. Generally speaking, feeding with the cutter is unsatisfactory, because the cutter tends to pick up whatever lost motion there is in the machine, and it does not seem possible to make a machine without some lost motion. That creates a tendency to gouge, and causes trouble. It is good practice to always feed against the cutter.

On bar work, such as described, if it is of similar nature and the results desired are merely roughing, it can be done, but some caution is necessary. It is not recommended, because an operator may go ahead without thinking of all the things that he ought to think about, and get into trouble. It really is not the proper way to mill. The feed should always be against the cutter.

The paper previously referred to by Mr. DeLeeuw, presented at the last May meeting of the American Society of Mechanical Engineers, held at Pittsburgh, included actual working drawings of a lot of these cutters, and gave as fully as possible in the space allotted, a discussion of these cutters, and the underlying principles on which their design is based.

Water Purification

PURIFICATION OF WATER BY FILTRATION

By R. Winthrop Pratt, M. Am. Soc. C. E.

The filtration of public water supplies for the purpose of removing sediment and other impurities has been practiced in Europe, especially in England, for the last 60 or 70 years, or more.

The method used was what is now called the slow sand system, and consisted in passing the water through sand beds at relatively slow rates; and without first using chemicals to produce a coagulation of the impurities. European methods of filtration were proposed for use in this country, as early as 1866, and during the few years following were installed in several of our smaller cities. In some cases, where the character of the water supply was similar to that of the English supplies, the filters were successful; but in other cases, where turbid waters were treated, success was not attained.

In 1890, the Massachusetts State Board of Health, at its Lawrence Experiment station began an extended investigation of the principles underlying the purification of water by filtration, and of the nature of the processes involved. Merrimac river water was used in these studies.

Three years later, in 1893, based on the results of the work at the Experiment station, and also following European precedent, a filter was built to purify the entire water supply of the city of Lawrence. This was the first filter in the United States, installed expressly for the purpose of reducing the typhoid fever death rate. Its success is well known—the typhoid death rate having been reduced some 80 per cent. This did much to stimulate interest in filtration in other American cities; and during the next few years the installation of filters of the slow sand type was begun by Albany, Washington, Philadelphia and Pittsburg.

About 1884, there was invented the American or Mechanical system of water filtration. The essential features of this method were, and still are, first, the addition of a coagulant to the water before it is applied to the filtering material; second, the passage of the water through the sand layer at a rapid rate; third, provision for cleaning the sand layer in place, by means of a reverse current of water instead of removing the dirty sand, as with the slow sand system.

Mechanical filters were first used principally by paper manufacturers, who required a clear water. Their use as a means of

hygienically purifying the water was not generally begun until within the last 10 or 12 years. The efficiency of the principles of mechanical filtration for municipal supplies was perhaps first proven during experimental tests at Louisville and Cincinnati, in 1897 and 1898. These cities are representative of a large class in the middle west, which has to use a clay-bearing water, and one that cannot be purified bacterially, or even clarified by the slow sand system. The development of mechanical filtration to its present state of efficiency has been necessary to meet the demands of such cities.

The cost of installing filter plants may range from $10,000 to $40,000 or even $50,000 per 1,000,000 gallons capacity. This unit cost varies with the size of the plant, the character of the water to be treated, the expense necessary to connect with the existing water system, and other local considerations. For example, the cost of installing the raw water pumps would be much less in places along the Great Lakes than it would be on the Ohio river, where the water level fluctuates 50 or 60 feet.

Studies by the Ohio State Board of Health, of 11 filter plants in Ohio, namely, those at

	Cost per 1,000,000 Gal's.
Cincinnati	$49,830
Dennison	26,000
Elyria	10,000
Geneva	13,000
Lorain	12,000
Marietta	10,000
Rocky River	14,000
Upper Sandusky	15,000
Vermilion	8,000
Warren	13,000
Youngstown	13,000

have shown the average cost per 1,000,000 gallons capacity to be about $17,000. Excluding the Cincinnati plant, however, which cost $49,830 per 1,000,000 gallons capacity, the average cost of the remaining ten is only $13,000 per 1,000,000 gallons capacity. The average cost per capita (based on ultimate capacity of plant), excluding Cincinnati, was found to be about $1.50.

Slow sand filters are in general more costly to build, but cheaper to operate than mechanical filters. This statement is made with the assumption, of course, that the slow sand filters are installed only where the water is sufficiently clear to enable them to be operated with reasonable periods of service between cleanings.

Operating costs vary greatly with the quality of the raw water and the character of the treatment. Lake waters drawn from points removed from shore, are cheapest to treat; while muddy river waters are most expensive.

Special treatment to remove color or odor add to the cost; and water softening may increase it two or three times. Under ordinary conditions filtered water may be obtained at a cost of $10 per 1,000,000 gallons, including interest and depreciation charges. This figure will vary from $5 to $20.

With slow sand filters the principal operating cost is the labor and maintenance of equipment used for washing the sand. With

mechanical filtration, the cost of chemicals and of labor, which are about equal, constitute the largest items.

In Ohio, it was found that the operating costs, excluding interest charges, ranged from \$2.55 per 1,000,000 gallons at Elyria to \$12.10 at Warren, with Youngstown second highest at \$10.67. This great difference in cost is largely due to the superior quality of Lake Erie water taken from a point fairly remote from pollution, over that of the turbid and polluted Mahoning river.

In considering the cost of maintaining a filter plant, attention should be directed to the comparatively small increase in the cost of supplying filtered water over that of supplying unfiltered water. This increase is rarely more than 25 or 30 per cent, and frequently only 10 or 15 per cent. In any case, the increase should not amount to more than 50 cents to \$2 per person per year—a small price to pay for enjoying pure water and all of its benefits.

DISINFECTION OF WATER BY CHEMICALS

By Dr. R. G. Perkins.

This term is to be translated more or less literally, as it means merely getting rid of all forms of animal or plant life, which may set up disease or give rise to unpleasant conditions of the water.

Removal of the *non-pathogenic* varieties was the first of the uses to which chemical disinfection was put and while at first great things were claimed for the various processes, certain difficulties were found to be present which have modified our actions to a large extent. Of the various chemicals used, the only one which has at present a practical use is copper sulphate, which is used for clearing reservoirs from the fresh water algae which develop in them, especially in the warm weather. In most cases, a strength of about one part of copper sulphate to the million parts of water is sufficient to destroy all the algae, and to leave the water clear after the dead forms have disappeared. It must be considered, however, that it has been found in many cases that the algae return in increased numbers after a short interval, and in others that there are resistant forms which cannot be killed by a dilution which will not be injurious to higher forms of life. The earlier claims that this method would kill pathogenic bacteria in the above dilutions have not been substantiated.

We are at present more interested in the disinfection of water from the standpoint of removal of the *pathogenic* forms, especially those of the type of typhoid, Asiatic cholera, dysentery, etc. The essential of a successful disinfection would obviously be the total and constant destruction of all of these organisms by the use of quantities of the chemical which would be so small as to cause no danger per se, or interfere with domestic or commercial uses of the water. There are then certain definite indications for the use of a disinfectant, and even for the period of use and the

strength of the chemical. There are in general three sets of circumstances leading to disinfection:

1. Impure water with no immediate prospect of permanent improvement. Here the use should be continued until the establishment of a permanent safe supply.

2. Where there is a water supply which has been made safe by filtration or other means, there should be an emergency apparatus at hand for temporary treatment in case of accident to the plant.

3. Where there is a properly constructed filtration plant treating polluted water, it is now considered best to use a small amount of disinfectant *after* the filtration to protect against any possible errors.

With these points as the essential indications for disinfection, one may consider the choice of an agent. Ozone and chlorine are the chief chemical agents to be considered, since the ultra-violet ray is rather physical than chemical. One may say in passing that the latter is entirely unsuitable for our purposes in Cleveland since it will work only in a clear water, necessitating preliminary filtration.

Ozone and *chlorine* then are left, and they act by the setting free of molecules of so-called *nascent oxygen,* which has an oxidizing power of extraordinary strength. When water is treated by these agents, the nascent oxygen attacks all organic matter with great vigor, and inasmuch as the effect is in direct proportion to the exposed surface, it is clear that bacteria, being very finely divided organic matter, will be among the first to be oxidized. There is thus no specific action, but the pathogenic germs share the fate of the inert organic matter. The germs, however, are more or less well equipped to meet harmful influence and it thus happens that a very definite amount is necessary, and that some varieties are more resistant than others. Fortunately the varieties which cause the water-borne diseases are among the least resistant.

Both these methods have been extensively tried, and both have their good and bad points. From the enormous increase of the use of chlorine as against the very slow spread of the use of ozone it is clear that the apparent advantages are on the side of the former. Ozone is procured by the passage of an arc through dry air and then passing this air through the water to be treated. The difficulties are: *First*—the need of an expensive and more or less complex apparatus; *Second*—the necessity of *dry* air, requiring a special drying apparatus in addition to the other; *Third*—the need of a storage reservoir, as there is no other possibility of reserve; *Fourth*—that the method is not at all standardized.

The main advantage is that the public is so pleased at the idea of the use of life-giving oxygen that it offers no objection to the use of the chemical, though this in greater strengths is a definite poison.

The objections to the use of chlorine, leaving out for the present those without foundation, are: *First*—the introduction of a chemical with a disagreeable odor, taste and associations; *Second*—the use of a chemical which is known to have corrosive and bleaching powers.

The advantages of chlorine are the cheapness and simplicity of the process which are not approached by any other method, the standardization, the fact that even where a power mixing plant is used, hand mixing could be readily resorted to, so that there is no danger of an interruption of the dosing.

Neither process affects the turbidity, the hardness or the general appearance of the water.

It is the opinion of most sanitarians that ozone is still in the experimental stage and that chlorine is a disinfectant which has practically revolutionized the water problem. In the United States alone there are over two hundred places which are using the method, and there is a very large and increasing number abroad.

One may use chlorine in the form of gas under pressure and there are special apparatuses on the market for the dosage. One may make the gas by electrolysis of salt water, or one may use the commercial *chloride of lime*, also known as bleaching powder, which is made by the saturation of lime with the chlorine formed in the process of manufacture of caustic soda by the aforesaid electrolytic method. For practical purposes the chloride of lime has been found most useful, though there are certain definite advantages in the electrolytic chlorine.

Whatever the method by which the active agent is obtained, it is always the same, and is spoken of as *available chlorine*. Moreover, the active strength is also the same, as established by a large amount of experimental work, and as a result of this work one may say that a proportion of one part of available chlorine to one million parts of water will destroy all the germs of water-borne diseases. As the result depends on the action on organic matter *as such* it is clear that the amount of organic matter normally present in the water will have a bearing on the proper dosage, and that waters with a great variation in the organic content, as is true of our water here, will require a greater factor of safety than others.

The fact of perhaps greatest importance is that there is apparently a *critical* point in dosage, at which satisfactory results will be obtained, but below which it is not safe to go. With the Cleveland water it was found experimentally, for instance, that 0.6 to 1,000,000 was adequate but that 0.5 was not. Moreover it is also true that a marked excess over this point is of no value as the total efficiency has already been obtained. Continuance of the experiments indicated that 0.7 allowed the necessary factor of safety, except under extraordinary conditions, when it will be advisable to make a temporary increase.

When the chlorine is put into the water where there is chance for aeration, as at the entrance to a reservoir, there is a very rapid action and a very rapid disappearance of smell and taste, but where the circumstances are as in Cleveland, with the actual place of intake inaccessible during a large part of the year, this ideal method cannot be used. Accordingly it is necessary to put the chemical into the pump well, where there is an interval of less than five minutes before it goes under pressure. The killing effect has been satisfactory at this time, but the taste persists for a time dependent mainly on the temperature of the water, lasting longer

in cold water, ordinarily from 30 minutes to an hour, while the odor persists practically until the water is released from pressure at the tap. The amount of odor will decrease with the increase of time from the intake and at distant points will be only appreciable by keen senses, while at nearer points it may be readily smelt, for instance, at the time of the morning bath. The actual disappearance is rapid, tests showing that when samples are taken at once and after five minutes there is already a decrease of nearly 50 per cent, and when the water reaches the consumer there is present less than one part in ten million, so high a dilution that to scientific men it is hardly necessary to point out the absence of danger.

Wherever the method has been tried, it has proved successful in reducing the water-borne diseases, and this has been notably the case in Cleveland, where at the time of introduction of the process, there were all the weather and water conditions suitable for the development of a serious epidemic, which, however, failed to appear. The typhoid rate in December has been the lowest for many years, though the general water conditions have been very unfavorable. In fine, the results of chemical treatment with chlorine have been found here and elsewhere to reduce typhoid to a very large extent and to reduce the pollution of the water as indicated by the *daily* tests at the city laboratory, which have been carried on since 1904, while there has been absolutely no positive evidence of the slightest ill results to persons who drink the water. The objections are in the main sentimental, and at times hysterical, but all the *proof* lies on one side of the case.

NOTE.—Cost of process. Apparatus for small communities pumping 200,000 to 500,000 gallons a day may be established for less than $25. Where there is a reservoir, very large quantities may be treated at a very low cost, and the only real expense lies in the establishment of the large tanks and the power mixer advisable for large communities. The cost of the Cleveland plant was $4,143.68.

The cost of the bleach is usually from $20 to $25 a ton, and roughly one-third of this represents the *available chlorine*. With the weight of a gallon as eight and one-third pounds one may calculate twenty-five pounds of the powder as able to disinfect one million gallons at a strength of one part in the million. From this the daily cost may be readily computed. Tests of the bleach should be frequent to check irregularities. The dosing outfit should be so arranged as to prevent the ingress of any of the sediment and should allow of flexibility in flow in case of changes in pumpage or in the quality of the water.

PURIFICATION BY OZONE

THE DESTRUCTION OF PATHEOGENIC BACTERIA IN WATER BY THE APPLICATION OF OZONE

BY R. M. LEGGETT

(*Paper read by R. H. Klauder.*)

One of the most convincing arguments in favor of our advanced civilization lies in the fact that governments, both national and municipal, have taken to themselves the task of guarding the public health.

A sick or dead citizen ceases to be an asset to any community, and in a great many instances becomes a liability. The trend of modern medicine is to prevent disease, to teach people how to keep well, more than to make them well when stricken.

Thus, modern conditions place responsibilities upon cities that did not exist a decade ago. The city governments today are responsible, to a great extent, for the health and safety of every citizen. They supply an adequate police force to protect the public in so far as it is possible to do so, they provide asylums for the insane and hospitals for the sick, but so far as public health is concerned, a great many cities lock the stable door after the horse has been stolen. This they do by compelling the citizens to drink water containing sewage pollution and disease producing bacteria. To quote Ellice Hopkins, "It is better to fence the precipice at the top, than to wait with an ambulance at the bottom."

The majority of American citizens have learned by very bitter experience that it is costly to provide for their inhabitants a polluted drinking water.

Very rapid strides have been made by sanitary engineers in the last 10 years, and their labors have resulted in placing at the disposal of cities various devices having as their object the purification of water.

Water purification embraces two principle acts, first, the removal of matter in suspension; second, the destruction of matter in solution.

Suspended matter comprises:

First—The grosser particles, such as clay, sand, leaves and parts of dead fish, sewage, etc.

Second—Micro-organisms.

Third—Bacteria.

The soluable content is composed of the organic compounds due to animal and vegetable decomposition, and mineral contamination from factories, and natural conditions of soil and rock.

In all problems of water purification, we have first to deal with that which causes disease, and after that, with those contents that cause unpleasant but harmless odors, colors and tastes.

The water to be treated by ozone must usually first be passed through a rapid roughing filter. This simply acts as a strainer, removing the grosser matter in suspension. Particles of sewage, dead leaves and organic matter absorb so much ozone, that if present in the water to be treated, reduce the efficiency of the system, unless first removed in this way.

If the pre-filter removes the gross matter, the ozone will remove the bacteria and the organic matter in solution, the effluent being clear, pure and free from odor, color or taste.

Ozonization is but another name for oxidation and it is by rapid and more or less complete oxidation that the desired results are accomplished.

Ozone is allotropic oxygen expressed by the symbol O_3, as distinguished from oxygen, O_2. It is an unstable form that tends to give up its extra atom.

Bacteria are composed of about 86 per cent water and 18

per cent of organic matter, 6 to 8 per cent of which is carbon. The contact of these bacteria with ozone spells their instant destruction, as the carbon is reduced by oxidation to carbonic acid, the water is freed from the organic matter and we have as a result, water, carbonic acid and nitrous and nitric oxides.

In water highly contaminated with mineral salts, these gases may very slightly increase the nitrates and carbonates, but on such a minute scale as to be hardly detectable by analysis.

It has been estimated that one million bacteria represent one-sixteenth of a milligram total weight, of which as stated 80 to 86 per cent is water and the rest carbon.

The average untreated, natural water contains from 1,000 to 10,000 bacteria per cubic centimeter, which represents so small an amount of carbon as to make its products of oxidation negligible.

Various devices are in use for the production of ozone, but in all, the object is to bring a current of air in contact with the silent discharge of a high-tension current of electricity.

The ozonizers in use in the Ann Arbor plant are of the tubular type, and consist of 109 tubes. They are 35 inches long and 24 inches in diameter. There are three of these ozonizers, two of which are in operation all of the time, and one is kept ready in case of emergency. The ozonizers are simply steel shells, containing 2-inch aluminum tubes, about 30 inches long, rolled in, and have the appearance of small fire tube boilers. Inside these tubes are mica tubes for the dielectrics and inside the mica tubes are other aluminum tubes. The discharge takes place between the two aluminum tubes and the dielectric. The space in each case is about 1/16 inch, through which the air is passed.

The ozonizers are enclosed in steel tanks which have a circular dam in the middle, which forms two compartments. One compartment is the receiving end, where air under pressure from an air compressor is taken in and passed through the ozonizer. Part of its oxygen is converted into ozone and the air then passes along, as required, to the sterilizing towers.

After the air is compressed, it is passed through a cooler, thus preventing any heating of the ozonizer due to the discharge. It must be explained that only a small percentage of the energy applied to the ozonizer is utilized in the production of ozone. The greater part is lost.

Just as ozonizers are various in their form, so are, to no less extent, the means for applying the ozonized air to the water. The problem is evidently to produce a thorough mixture and in the methods in successful use there are two fundamentally different ways of doing this. In one the water is finely subdivided and passed through the ozonized air and in the other, on the contrary, the air is subdivided and passed through the water. The Ann Arbor plant belongs to the second class.

The ozonized air is conveyed to the sterilizing towers, which are built in batteries of a size to meet the capacity demanded. These towers are built on steps, with a fall of 3½ feet between each step. The water is taken in at the top of No. 1 tower, at the bottom of which are arranged suitable spray nozzles for the

introduction of the ozonized air. Each tower contains four baffle plates that compel the water to travel 57 feet in each 13 feet of tower. This prolongs the contact of the water and ozone and enhances the efficiency of the system. The water leaves the bottom of No. 1 tower and enters the top of No. 2 tower, 3½ feet lower, where the same operation is repeated, and so on to No. 3 and No. 4 tower.

The chief advantages of the ozone system over any other known system of water purification lie in economy of operation, constancy of action, and freedom from costly repairs and renewals.

Nothing is added to the water to cause it to have an unpleasant taste.

No deleterious by-products are formed and odors and tastes due to organic matter are destroyed. Filtration by any means is only a greater or less reduction in the bacteria contained in the raw water. This percentage may be as high as 99 per cent when everything is working right, but the remaining 1 per cent in a highly polluted water may represent a grave danger. Filtration exerts no selective action. It removes the same percentage of pathogenic organism as it does of the harmless ones.

Ozone, on the contrary, has a selective action, killing all the pathogenic germs and practically all of the others. This is due to the low power of resistance to oxidation of the pathogenic germs and is confirmed by the statistics of various places where ozonization has been introduced. Paderborn, Germany, had a typhoid rate of about 1,500 per 1,000,000 population. Filtration reduced this rate tto 290, and ozonization still further reduced it to zero. This plant was built in 1897 and has been in continuous operation since that time. Similar results have also been recorded in Paris, Dinard, Chartres, Nice, Weisbaden and other European cities.

In conclusion, it may be stated that any municipality using surface water may render this water safe by ozonization properly applied as outlined above.

THE ELECTRIC PURIFICATION OF WATER

By D. D. Vincent.

The pollution of the sources from which our great cities draw their water, and the sickness and loss resulting from the use of impure water, has drawn the attention of scientists and engineers to the various methods proposed for the purification of such water as is available.

Your attention is invited to the electrical purification of water, as practiced by the Electra Pure Water Co., of this city, with which I am associated, as this method produces an ideal table water, free from organic matter, but not devoid of the necessary mineral salts.

Water purified by this process is taken from the city mains under pressure and passed between aluminum plates which are

connected to a suitable source of electrical supply. It is then filtered through crushed quartz while still under pressure. We do not know today all of the changes which take place in the presence of the current. We do know, however, that a small percentage of the water is decomposed and that the organic matter in the water is oxidized and coagulated by the oxygen which is released and that the hydrogen combines with minerals in solution forming flakes of solid matter which can be removed with the organic matter by filtration. Repeated tests have shown that colon bacilli will not survive in this water any longer than in distilled water.

Exact work is being undertaken to establish the best practice in using this method of purification, both as to the form of apparatus used and the most economical current density and we are convinced that the cost of purification can be reduced to such a low figure as to give this method of purification a very wide application.

Discussion

Langdon Pearse*: —

The previous speakers have given a general review of the field of water purification. Mr. Pratt has shown you what the processes of filtration are, and the cost.

Mr. Leggett's paper covers the ozone plant as erected at Ann Arbor. The ozone process, as a means of sterilization, is not yet on a commercial basis in this country, in that a plant cannot be operated continuously to give uniform results, nor is it economical. This was conclusively shown by careful independent tests, made at Jerome Park reservoir, for the city of New York several years ago. Sterilization by hypochlorite of lime is much cheaper and more dependable. Ozone treatment was considered for the city of Montreal, but Messrs. Hering and Fuller in their report distinctly state that it is not yet on a basis to merit recommendation.

The paper by Mr. Vincent describes a process for the purification of water, based on making electrolytically aluminum hydrate. Instead of adding sulphate of aluminum the hydrate is made by passing an electric current between two plates. This simply coagulates the water, and a filter is essential both to remove the turbidity and the bacteria. There is no virtue in the electric current. It is cheaper to buy the sulphate of aluminum and apply it in the usual way. In the Louisville report, in 1896, Mr. George W. Fuller examined this general process very carefully, with extended tests, and concluded that it was impracticable, and extremely uneconomical.

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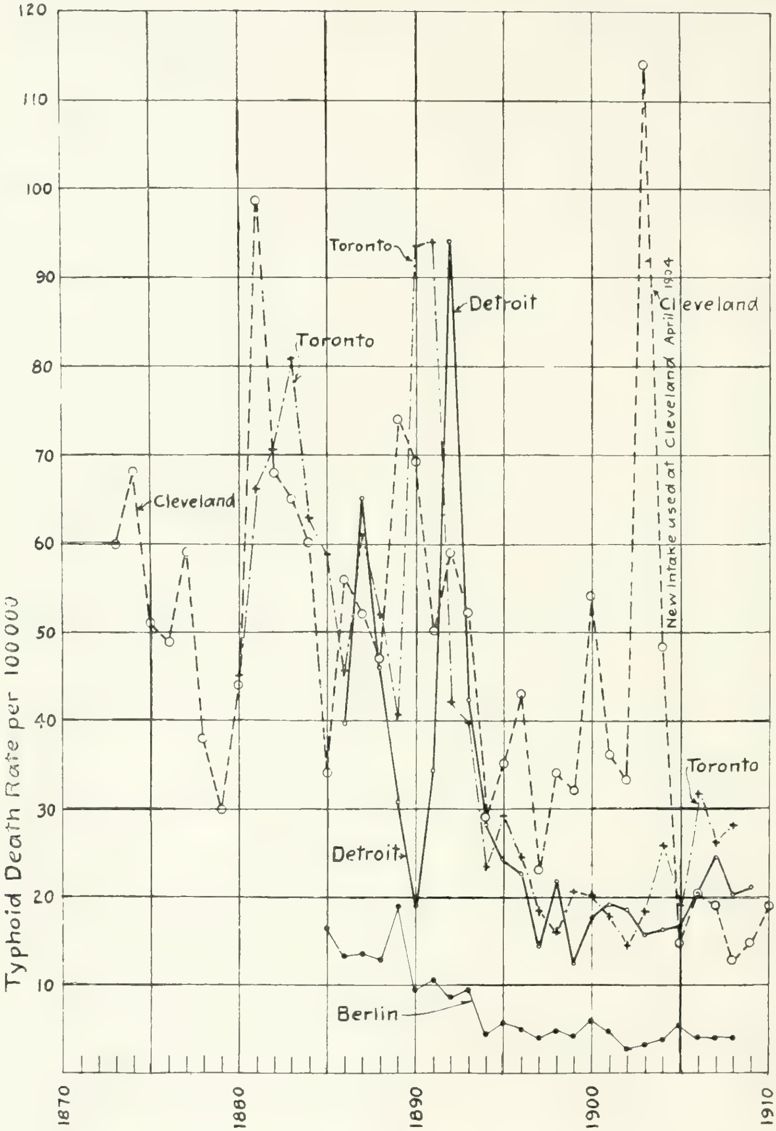
Sanitary engineers today recognize that the only tried and effective means of treating a water supply to remove bacteria and turbidity, are sedimentation followed by slow sand or rapid filtration. A coagulant may be used at times with a slow sand filter, and is always required for the rapid filter. As a finishing process, chloride of lime is available to sterilize. Alone it serves as an emergency process. It does not affect the turbidity.

The situation in Cleveland is of great interest to me, as I represented Mr. Whipple for two months, in 1903. I have followed the situation since. At that time we felt that filtration would undoubtedly be required. How soon, we could not say, as the four-mile crib had only been in operation two or three months, and the sewage had not been intercepted, as originally planned. With the data available, Mr. Whipple reported that filtration would probably be required in a few years. Even if the sewage was removed from the Cuyahoga and the water front and discharged at a point some nine miles to the east of the crib, the crib would still be exposed to occasional pollution. Sewage is still flowing into the Cuyahoga in amount some 40 per cent of the entire discharge.

Personally, I have never understood why the four-mile crib in Cleveland was located directly in front of the Cuyahoga, even though four miles off shore. Recent tests for the Lake Michigan Water Commission have shown that under favorable conditions a sewage stream may work out even 10 miles from shore before finally dispersing. The Cleveland water supply is turbid at times, and is undoubtedly open to suspicion on the ground of bacterial pollution. I have not had a chance to examine the data at hand. I do feel, however, that if there is conflicting data, all hands should get together at once and urge the appointment of a disinterested expert, a sanitary engineer of high standing, to examine into the case in the light of developments since 1903, and report whether or not filtration is not immediately advisable, particularly as the sewage has not been diverted from the Cuyahoga, and may not be for some years to come.

In the meantime, systematic data should be collected daily, particularly on the turbidity of the lake water, as taken from the tunnel at Kirtland street pumping station, its temperature, alkalinity, and bacterial content, in order to have data on hand to help in determining the filter problem. Possibly Mr. Pratt proposes to do this. It would also be very easy for him, in connection with a sewage experiment station, to build two or three small experimental water filters, and try out slow sand and mechanical filters at Kirtland street, in order to have a line on their adaptation to Cleveland conditions.

About eight months ago, in a talk at Detroit, and later before the Illinois Water Supply Association I showed a diagram on which was plotted the typhoid fever death rate of Detroit, Toronto, Cleveland and Berlin. Toronto and Cleveland both have an uneven rate. Berlin has a rate extremely low and consistently so. (See diagram.) At that time I pointed out that the Cleveland supply was open to suspicion. From what I have heard during



Typhoid Fever Death Rate per 100 000 at Cleveland Detroit Toronto and Berlin

the last two days I am convinced that immediate steps should be taken to determine whether filtration is required, at once, and to make the proper moves to finance the project, if it is required. Chloride of lime is an excellent emergency expedient to sterilize the water, and is now in use at the temporary plant.

With the modern standards of sanitation it is essential that a city have a clear water supply, always free from turbidity, and above suspicion of bacterial pollution. This is not only a valuable asset, an advertisement of progressiveness, which appeals alike to commercial men and homeseekers, as well as to residents, but is also a distinct gain to the public health, since abundant statistics point to a marked reduction in the general death rate with the accompanying reduction of the typhoid rate, when a pure water supply is introduced. The yearly saving in lives, if estimated at $5,000 each, would easily pay the interest on the cost of a filtration plant in many cases. If 40 lives can be saved yearly, this would amount to $200,000, which capitalized at 5 per cent is $4,000,000.

The situation in Cleveland is not unique, but is a common one around the Great Lakes today, where a city has to discharge its sewage into the source of water supply. Chicago is the only city which can successfully divert the sewage. That is the scheme we are following today, as laid down by Mr. Hering in 1885. Recent investigations have shown that, with the unexpected increase in industrial wastes as well as human pollution, the rate of 3.3 cubic feet per second per 1,000 population is not sufficient. We feel, however, that the work was excellently planned, and has fulfilled its purpose. A recent report by Mr. Wisner, our chief engineer, has outlined the means open to us to increase the dilution capacity by settling the sewage in Emscher tanks. Some work must be done at once on the industrial wastes and the city sewage, since the capacity, in accordance with our legal ratio of dilution, will be exhausted in 1922. We have been operating a testing station for over two years, and carrying along preliminary studies in the various schemes.

Milwaukee is now facing the problem. There the entire sewage of the city is flushed out into the lake, two and a half miles from the water intake. Filtration of the water has been recommended, with the removal of the sewage from the river and its diversion to a point about nine miles from the intake, where, later, settling basins, and finally, sprinkling filters will be required.

In Toronto the water supply is to be filtered, with slow sand filters, recommended, by the way, by Messrs. Hazen and Whipple, and the sewage is to be diverted to a point some three and a half miles to the east, where it is to be settled and perhaps disinfected before discharge into the lake. Dr. Amyot can tell you more of the details.

In conclusion, I may sum up by saying that it is recognized today that filtration of a water supply, either by slow sand or rapid filters, according to conditions, will remove impartially 95 per cent or more of the bacteria, and the turbidity. A small amount of hypochlorite of calcium will remove practically all the remaining bacteria. The situation in Cleveland demands a most

careful, unbiased investigation, at once, in order to fix whether the available data warrant the immediate expenditure of the sum required for filtration. Conditions have changed since 1903. In matters appertaining to the public health, delay is dangerous. Sterilization with chloride of lime will, however, furnish temporary protection until the decision is rendered.

Rubber

By Dr. W. C. Geer.

I. Crude Rubber:—

The first historical reference to rubber was in 1525, by a Spanish writer, who described some rubber ball playing seen by him in Mexico. In 1731, the Paris Academy of Science sent an expedition to South America to obtain certain geographical measurements and they brought back specimens of rubber. They found a tree called Hevea by the natives, which gave forth a milk-white liquor which hardened and blackened in the air. They found the natives coating linen with this material and making watertight boots. Samples came into England about 1770, and Priestley, the chemist, recommended it for the purpose of erasing pencil marks; hence, the name rubber. Since it came through the West Indies it was called India rubber, although this term is today a misnomer.

Sources of Crude Rubber.

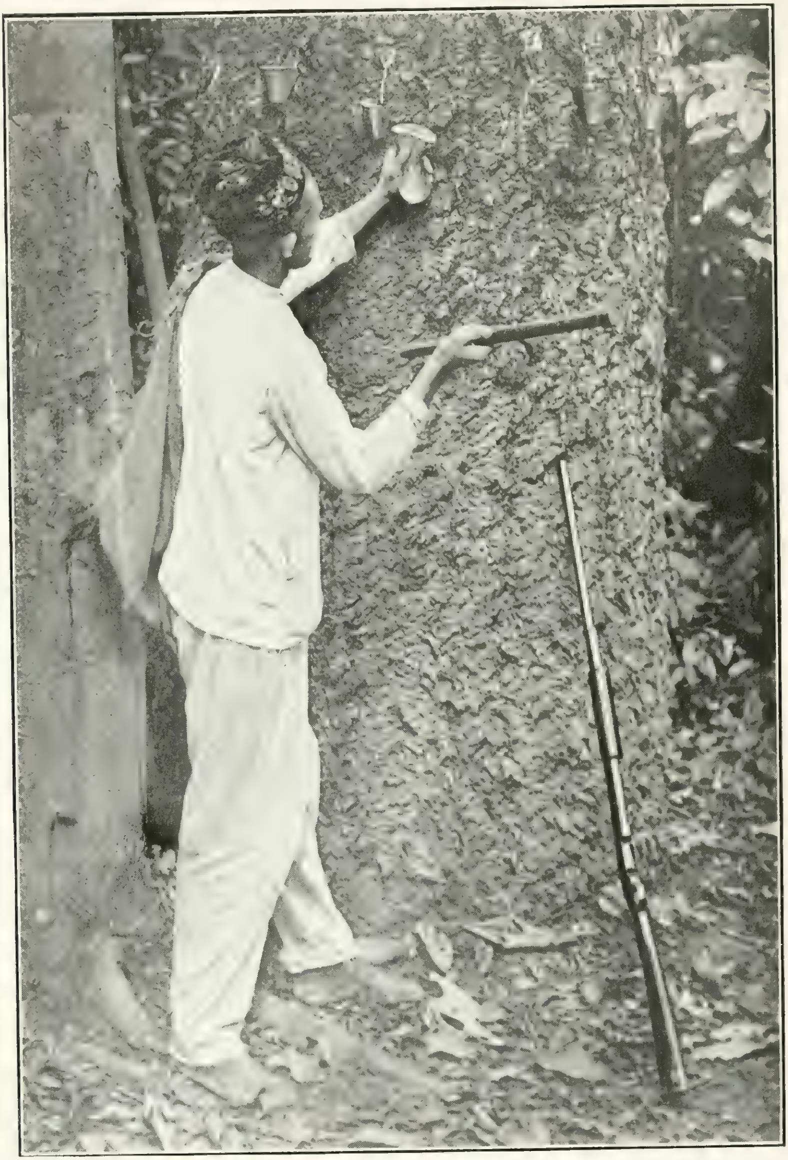
Rubber bearing plants are found in considerable tracts of tropical and sub-tropical zones in South and Central America, Asia, Africa and Australia. The species are very numerous. The chief botanical orders are: Euphorbiaceae, Apocynaceae, Urticaceae, and Compositae.

Of the Euphorbiaceae, the most important is the genus, Hevea, from the species Hevea-brasiliensis, of which about 60 per cent of the world's total output of rubber is obtained. It is predominant over large tracts of South America, in the Amazon valley particularly. In the natural state it is a large tree growing to the height of 100 feet and a diameter up to 40 inches. It has been frequently stated that not more than a small proportion of the trees in the vast forests bordering the Amazon, the Rio Negro and Rio Madeira, etc., have been exploited.

The trees are tapped by means of a small iron hatchet, having a blade about 1 inch broad, making incisions, deep cuts and oblique lines. There are a large number of methods of tapping. About 35 consecutive daily tappings are necessary. Small collecting cups are fixed to the tree by means of moist clay. The rubber runs out then in the form of a white milk or latex into these cups. An average annual yield in the Amazon is 5 pounds of dry rubber, although very variable. The latex is then transferred from the collecting cups into pails and from the latter into a flat basin and then it is coagulated by means of the smoking process.

A fire is made of a material giving a rich, dense smoke, particularly the fruit of the Urucuri palm. A small quantity of the latex is poured on a long pole which is rotated in the smoke until it is dried or "cured", then a fresh quantity is poured on and

the rotation continued, and this operation is repeated until a biscuit or ball of rubber weighing from 20 to 100 pounds is formed. This ball consists of innumerable thin layers and forms the Fine



TAPPING TREES.

Para of Commerce. Other commercial varieties are: Cameta, Coarse, Mollendo, etc.

There are many grades of rubber produced in Africa, which belong to the order, chiefly *Apocynaceae*, of which the main

genera are: Funtumia, Landolphia and Clitandra. The Funtumia yield grades of rubber known in the trade as, Gold Coast Lumps, Ivory Coast Lumps, Niggers and some of the Congo and Cameroon varieties. It is a mature forest tree with a circumference of about 40 inches and rises to a height of from 40 to 50 feet. The Landolphia varieties are creepers and vines up to 6 inches in diameter, and give among others the well known commercial brands of the Congo varieties, red and black, Upper Congo Balls, Equateur, Madagascar, etc. The latex is coagulated in a variety of ways, sometimes by smearing the latex on the body and allowing the natural heat to evaporate the water and, subsequently, stripping the rubber; sometimes by boiling and smoking. Some of the ball rubbers are obtained by applying a coagulant, such as chalk, or by cutting the vine and drawing the thread of rubber thus obtained to form a core, subsequently winding more and more thread around the core until the ball is obtained. The vines are difficult to tap and, consequently, they are generally cut down and bled to death.

Urticaceae is an order from which many varieties of rubber are obtained from Asia, Mexico, South and Central America. The Ficus Elastica is found mainly in Asia, Borneo, Ceylon, Malaya, Java, India, etc., and yields the commercial grades of Assam, Java and Penang. It is generally collected from the trees in the form of scraps. The Castiloa species are found in Mexico and Central America and yield the Peruvian Caucho, the Mexican Strips and Centrals rubber.

The Compositae give us the Guayule rubber.

The *Plantation Industry* is most important. In 1876, the first large batch of trees was planted in Ceylon. Approximate acreage in rubber in Ceylon is as follows:

Year 1890	Acreage,	300
Year 1895	Acreage,	550
Year 1898	Acreage,	1,250
Year 1904	Acreage,	11,000
Year 1907	Acreage,	150,000
Year 1910	Acreage,	190,000

The total acreage under planted rubber in various parts of the world is estimated:

Countries.	Acreage.
Ceylon	200,000
Malay Peninsula	400,000
Java, Sumatra and Borneo	200,000
Southern India and Burmah	35,000
German Colonies	45 000
Mexico, Brazil, Africa and West Indies	100,000
Total	980,000

Schidrowitz, Rubber, page 41.

There is a great deal of diverse and misleading information regarding plantation rubbers, particularly with respect to the yield of rubber in pounds per tree or in pounds per acre and the profits which can be made from them. The estimated plantation production for 1916 is 92,000 tons. We will not enter into a discussion of plantation rubber, because that is a separate industry.

The Rubber Latex.

Under the microscope, it consists of a fluid with innumerable particles of globular shape. The constituents are various sugars, crystalline substances which are derivatives of oxygen, enzymes, water, rubber, resin, etc. A typical average analysis of a latex from Hevea-brasiliensis Ceylon showed:

Rubber	32.00 per cent
Resin	2.03 per cent
Proteid	2.03 per cent
Mineral matter	0.00 per cent
Sugars	0.00 per cent
Water	55.56 per cent

Coagulation involves physical and chemical changes not yet fully known.

The Chemistry of Crude Rubber.

The chemistry of crude rubber divides itself naturally into two divisions:

(*a*) That of the rubber hydro-carbon.
(*b*) That of the secondary constituents.

On analysis, the rubber hydro-carbon has been found to contain carbon and hydrogen in the proportions of the formula, $C_{10}H_{16}$, that is, it has the same ultimate chemical composition as the fundamental constituent of turpentine and of a vast number of other bodies known as "terpenes". It is a colloid and probably to its colloidal character may be ascribed its value. A great deal of work has been done during the past few years on the synthetic production of the rubber hydro-carbon. The literature contains a large number of articles and the patent literature is now becoming extended. It has, however, as yet not advanced to the stage when it may be called a large commercial proposition.

The chemistry of the secondary constituents includes those of the resins, which are found in the crude rubber. This term is a broad one to include substances which may be extracted from crude rubber by means of acetone and similar solvents. The amount of such resin varies in different crude rubbers and indeed varies in different lots of the same crude rubber. There is also contained, in very small quantities, certain mineral matters and numerous other, rather complicated, organic chemical bodies.

Crude rubber, as it comes into the market, includes both the pure hydro-carbon and secondary constituents as one body together. The specific gravity is about 0.90. It softens in the neighborhood of 245 degrees Fahr. and becomes clear liquid at about 370 degrees Fahr., although these figures are very variable, depending upon the particular grade of crude rubber that is examined and the treatment that the rubber has received up to the time that the test is made. Rubber swells and forms pseudo solutions with petroleum and coal-tar hydro-carbons, carbon bisulphide, carbon tetrachloride and other solvents, although it is insoluble in alcohol, acetone, and groups of solvents of a similar character. It is a soft, sticky, rather plastic material, possessing, when washed and dried, and sheeted together, but little tensile strength, it can be easily molded, the color is variable from the light yellow crepe

Ceylon and plantation rubbers, to the red from Africa and the black of other grades of African rubber, dark green Guayule from Mexico, amber brown of the Fine Para from South America, in its washed and dried condition. When a fresh biscuit is cut and the surface exposed to the air for the first time, the rubber is usually white in color. This white color rapidly changes to brown, or black on being exposed to the air. The details of the pure chemistry will be passed over and not included in this talk.

II. Vulcanization :—

The rubber industry was not an industry and probably would not have become one of any size had it not been for the remarkable discovery of the process of vulcanization by Goodyear in 1839 and again by Hancock in 1844. These gentlemen found that sulphur unites chemically with rubber and gives more highly developed properties than were possessed by the original unsulphured material.

The two samples, which will now be shown, illustrated this difference materially. (1) This is a mixture of rubber and sulphur, made into the form of a ring, but not vulcanized. This can be very easily broken by simply pulling in the fingers. Tests in the laboratory show a tensile strength of 211 pounds per square inch.

(2) This sample is of the same mixing, but vulcanized in the form of a ring. This cannot be broken in the fingers and upon testing in the laboratory it is found to have a tensile strength of 2,620 pounds per square inch, as well as a much greater length at the point of breaking. In other words, vulcanization has increased the tensile strength, has made the rubber more flexible without breaking and has also added the other property, namely, the resiliency, that is, the ability of the rubber when deformed to return to its original conformation. These properties are all possessed in a more marked degree after vulcanization than before.

To accomplish the process of vulcanization, the rubber and sulphur are mixed together by any method, usually, however, by two mixing rolls, then made into any desired form and finally heated to temperatures varying from 250 to 320 degrees Fahr. for a chosen length of time. After this heating it is found that the rubber has united with the sulphur and it is said to be vulcanized.

Vulcanization is also possible by means of the liquid sulphur monochloride (S_2Cl_2), which was discovered by Parkes in 1846, and by means of which rubber in thin sheets can be vulcanized at the ordinary room temperature. This, however, forms but a relatively small division of the rubber industry.

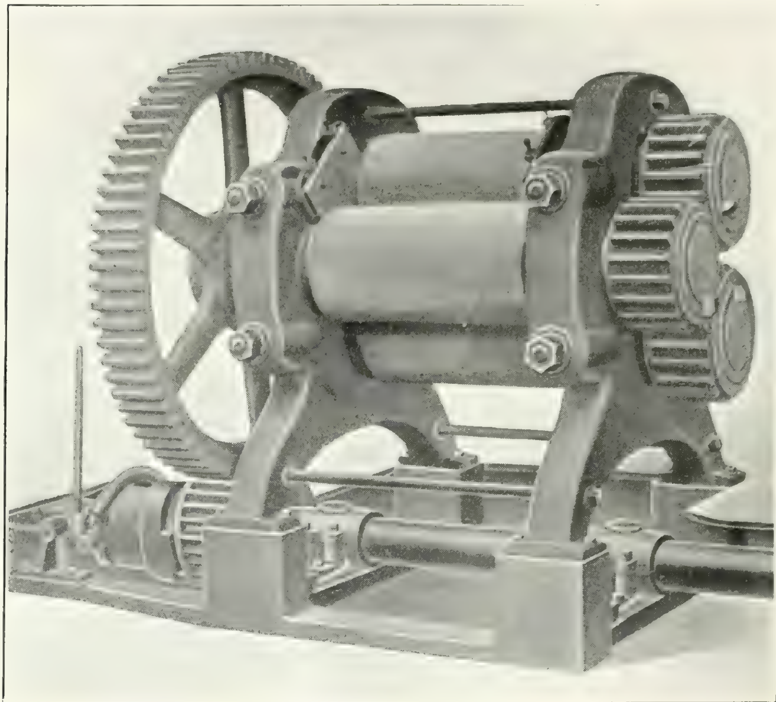
Other differences between vulcanized and unvulcanized rubber are numerous. Generally speaking, vulcanized rubber tends to deteriorate more rapidly than the unvulcanized rubber under similar conditions. Preserved in the dark and where cool, both vulcanized and unvulcanized rubber can be preserved for periods of many years. But at temperatures around 160 degrees Fahr., or over, they harden appreciably with age in a short time, and when exposed to the light, they undergo rapid oxidation. Dilute acids and alkalies do not attack them appreciably, but strong sulphuric

and strong nitric acids cause very rapid decomposition. Numerous oils cause a softening and weakening of the composition.

There are other physical and chemical properties of vulcanized rubber which, however, will be passed over, since they are details.

III. The Raw Materials of the Rubber Industry:—

Crude rubber and sulphur have been spoken of as two essentials. That is very true. However, in rubber mixings a large number of different materials of various kinds are used. Of these, reclaimed rubber occupies quite a prominent position. Reclaimed rubber is made from old vulcanized rubber, freeing it from the



Three-Roll Washer.

cloth made into the article and softening it. Numerous patented processes for this purpose are in vogue. It forms a very valuable material for rubber mixing of different purposes.

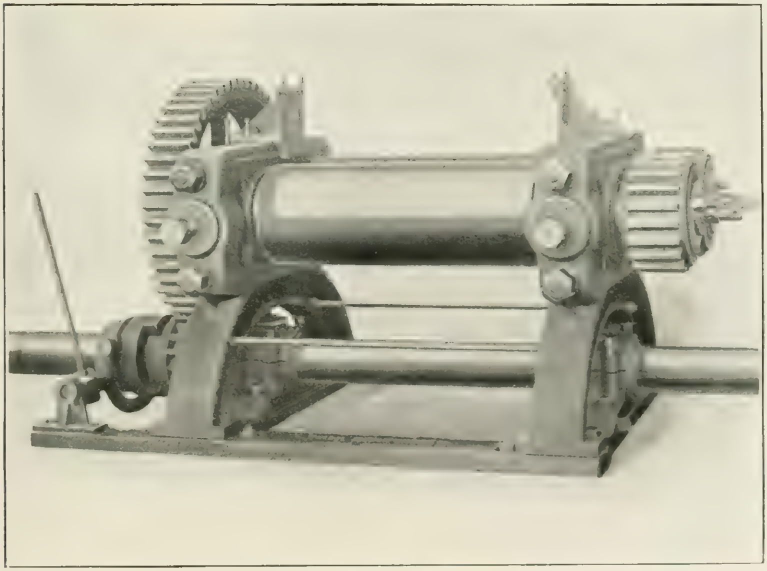
Rubber substitutes made by the oxidation or sulphurization of different drying oils are used to a limited extent.

Such dry mineral pigments as zinc oxide, lithopone, barytes, whiting, litharge, etc., have their own particular uses.

The rubber composition for any purpose, therefore, is not a mixture of rubber and sulphur alone, but of rubber, sulphur and those other materials which will give the highest service and the best value for the purpose for which they are intended.

There is a great deal of misinformation prevailing upon the

subject of the rubber compounding materials. It is perhaps generally believed that dry pigments are used merely for the purpose of cheapening and most people, when they hear of reclaimed rubber, consider it merely a matter of old scrap that is thrown back into the compound in order to increase the profits of the rubber manufacturer. This, however, is far from the actual truth. It is the purpose of the rubber manufacturer to produce articles which will serve the purpose in the best way, give the longest life and have the best value. One might desire to use mahogany for a building material, but it would scarcely be considered good judgment; on the other hand, pine is an excellent building material. Mahogany has its particular uses, oak has its particular uses, and pine has its particular uses. It is the same way with rubber. Each article is manufactured from a mixture that will give the best service and the best value. Of the large number of rubber articles,



Two-Roll Mixer.

hose, belting, packing, tires, water bottles, etc., each has certain definite uses and, consequently, the rubber compound or mixtures must be made according to the service for which each is to be put and the rubber manufacturer reaches his highest skill in so combining the different raw materials and manufacturing them into articles which will give the highest efficiency in service.

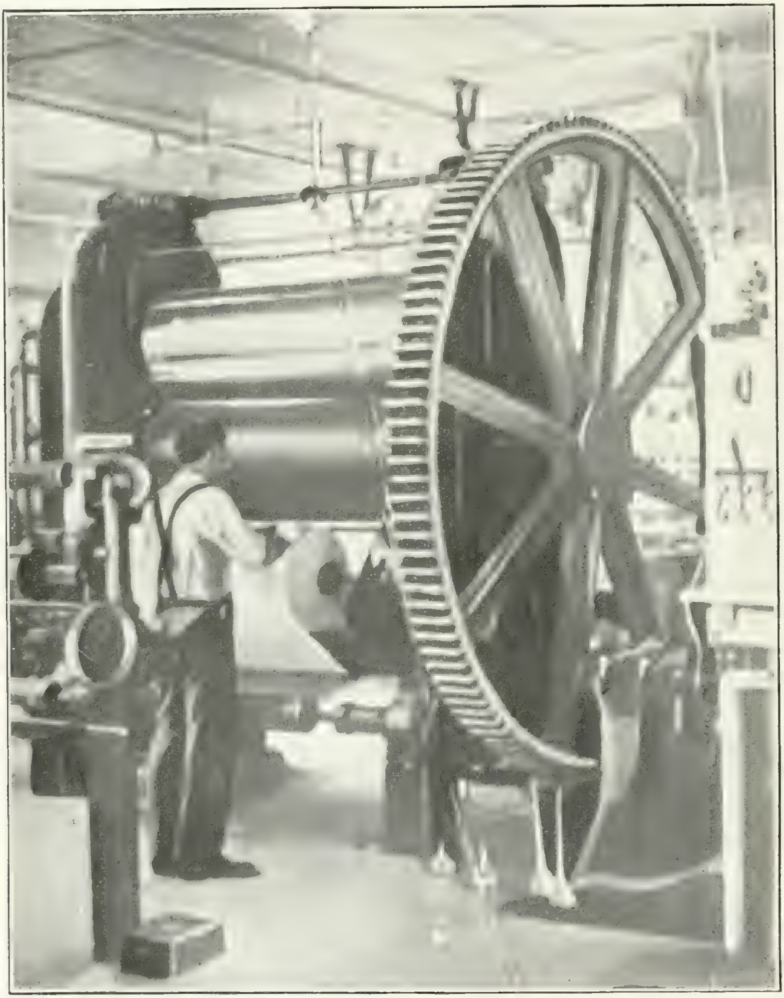
IV. Articles and Methods of Manufacture:—

The fundamental processes of rubber manufacture are:

(1) Washing crude rubber.
(2) Drying crude rubber.
(3) Mixing the ingredients of the composition.
(4) Calendering or otherwise preparing the rubber for vulcanization.
(5) Vulcanization.

1. *Washing.*

The crude rubber in the form of hams or biscuits or other forms, as it comes into the factory from the gathering fields is first reduced to the form of a thin sheet upon a washing mill, as shown in the photograph. It is then run between these rolls which are corrugated a number of times while water is allowed to fall



THREE-ROLL CALENDER.

upon the rubber. This gradually washes out the impurities, such as bark, etc.

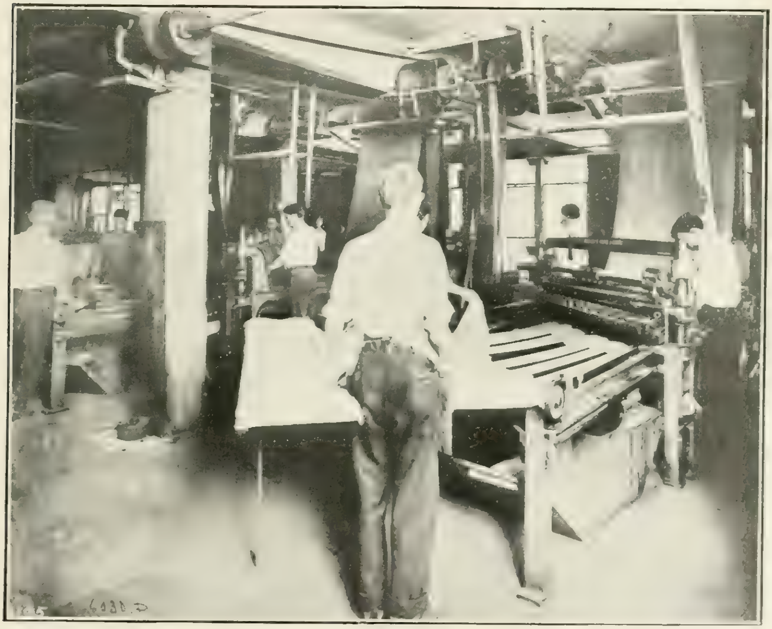
2. *Drying Process.*

Several different methods are used, notably, the method of hanging the large sheets over poles, something like hanging clothes, in driers which are heated by steam coils. Thus, in the course

of a few days the moisture is dried out of the rubber. Another method in wide use is the vacuum drier, in the use of which rubber is placed upon pans upon shelves inside a large closed container, from which, when filled with rubber, the air is exhausted by means of a vacuum pump. The plates, which are hollow, then have steam turned into them which heats the rubber, causing the moisture to be driven off in a very few hours.

3. *Mixing.*

After the rubber, sulphur and other materials are weighed up in the proper proportions, according to the recipe to be used, they are put upon mixing mills, a picture of which is shown. These are two rollers revolving close together in opposite directions, such that the rubber and other materials are brought between and



CUTTING.

squeezed. By a process of cutting off the rubber from the rolls of the mill and putting it in a different position on the mill the entire ingredients are thoroughly mixed together in the form of one homogeneous mass.

4. *Calendering or Preparing the Rubber.*

This mixture is sent to the calenders or to the tubing machines, by means of which the mixture is sheeted out a requisite thickness and width or run in the form of a tube or otherwise prepared for the final process, which is vulcanization.

5. *Vulcanization.*

The prepared rubber built up by hand in the form of an automobile tire, water bottles, belting or other articles, is placed in a

mold which is then squeezed between the platens of a hydraulic press and heated to the temperature of vulcanization. The fundamental idea of vulcanization as carried on in a rubber shop is that the rubber is formed in the mold in the shape which it is occupy when a finished article, and vulcanized in this shape. That is, the rubber materials forming an automobile tire shoe are contained within the sides of the mold in exactly the shape they will occupy when seen upon the automobile, and the process of vulcanization so changes the character of the rubber mixing that it retains this form and shape after it has been vulcanized.

It would be an impossibility within the time at our disposal to describe in detail the methods of manufacture of any number of rubber articles. You will be interested in the manufacture of

Making Tires.

automobile tires, of which several samples are shown. The fabric which makes up the body of the tire is passed through a calender and rubber forced or frictioned into the insterstices of the fabric. These frictioned fabrics are cut in the proper lengths and widths and wrapped on a core the exact size of the inside of the tire when finished. Upon the fabric thus put upon the core, layer after layer of rubber is carefully pressed down to the proper shape. This combined article is then placed in a mold, a number of which are put inside a steel shell and pressed under high hydraulic pressure. The steam is then turned in at the requisite temperature and the whole is allowed to vulcanize in the steam for the proper length of time. At the end of this time the press is opened, the molds removed, the parts of the mold taken away from the tire,

the tire separated from the core and the result is the finished article. The photographs show the making of tires and the operation of the tire presses.

The manufacture of truck tires for high duty service is by quite a different process.

In the manufacture of rubber hose, belting, air brake hose, etc., there is a particular technique for each article, the details of which it would be impossible for us to explain at this time.

V. Specifications for Rubber Articles, Chemical Analysis and Physical Examination to Determine Whether the Article Will Meet the Specifications:—

The Chemical Analysis of Vulcanized Rubber.

A sample of vulcanized rubber to be analyzed must first be ground or cut into very fine pieces. It is then, (1) submitted to the action of acetone which extracts resins, some oils and free sulphur. The free sulphur is then determined by standard chemical methods and the difference between that and the total amount of the extract is usually computed as resins. The residue is then, (2), extracted with pyridine which dissolves tar, pitch, bitumen, etc. The residue is then extracted, (3), with alcoholic potash which dissolves oxidized and sulphurized oils which are saponifiable. This shows, in other words, rubber substitute. The residue from the alcoholic potash extraction is then treated, by some chemists, with, (4), nitro-naphthaline which extracts rubber, gutta percha, balata, etc., and the final residue, sometimes, is extracted in, (5), boiling water to dissolve starch, sugar, etc., which leaves, (6), mineral matter, free carbon, cotton fibers, etc. Separate estimations are made to determine total sulphur. The methods of chemical analysis are, however, notably unreliable, and there is a vast difference between the figures obtained by processes such as these and those obtained by gravimetric and accurate volumetric determinations. It is an impossibility to distinguish between reclaimed rubbers and crude rubber. Consequently, no methods of chemical analysis can definitely prove or disprove the presence of any kind of crude rubber.

Physical Tests of Rubber Articles.

The most important division of the testing of rubber materials is the physical tests, of which tensile strength in pounds per square inch is, perhaps, the most trustworthy. It is unnecessary to enter into the details of physical testing methods before you engineers. The details are worked out to suit the peculiarities of the rubber, namely, a relatively low tensile strength, ranging from 100 to 4,000 pounds per square inch, and a very high elongation at the point of rupture, the elongation being from 150 to 1,500 per cent. The permanent elongation measured, usually 10 minutes after rupture, is a valuable property.

The size and shape of the test piece is of moment. In the railroad specifications, pieces are usually cut 1 inch wide throughout the entire length, but practical experience and scientific study has demonstrated that it is just as necessary in testing rubber samples to have enlarged ends as it is in testing steel samples.

The influence of small irregularities, pieces of dirt, etc., which are inevitable in any rubber goods, have such a tremendous influence upon the tensile strength that it is necessary that the part of the test piece held in the jaws of the machine be large. In Germany a very popular testing method is in the form of small rings, something similar, but smaller in size to the jar rings used in preserving fruits. It has the disadvantage, however, of a very small size and consequently a very low actual breaking strength. The influence of irregularities is very much more marked in pieces of this size than in larger pieces.

To determine the length of time by aging tests which a rubber article will last is important and much study is under way in this direction.

PRESSES.

Service tests, such as steaming for steam hose, treating with oils, etc., or materials to be subjected to those compounds are carried out only to a limited extent. This field, however, is of great value and will, undoubtedly, be extended in the future as a means of determining the value of articles.

Specifications.

You will, I am sure, be interested in some remarks upon the writing of specifications for rubber goods, for, I think, that those of you who are familiar with this branch of the industry will agree with me that there is no side of the rubber business which is so crudely worked out, nor one upon which accurate and reliable work can be done to greater advantage. When you or I desire to buy an article, it is quite natural that we, knowing the use to

which it is to be put, should establish a set of specifications. These specifications are intended to establish a standard for the article to which each purchase must measure to give us a uniform quality of the material or article. The importance of this matter is so great that it is of moment to determine the kind of specifications to draw and the kind of tests to prescribe. Obviously, such specifications and tests must be developed in the light of knowledge of the material to be specified.

There are two extremes of specifications:

(1) Specifying chemical composition, physical tests and services as is done in some United States Navy specifications.

2. The other specifying by one physical property which is done in the Master Car Builders' specifications for air brake hose.

Neither of these extremes will give the best article or the best value.

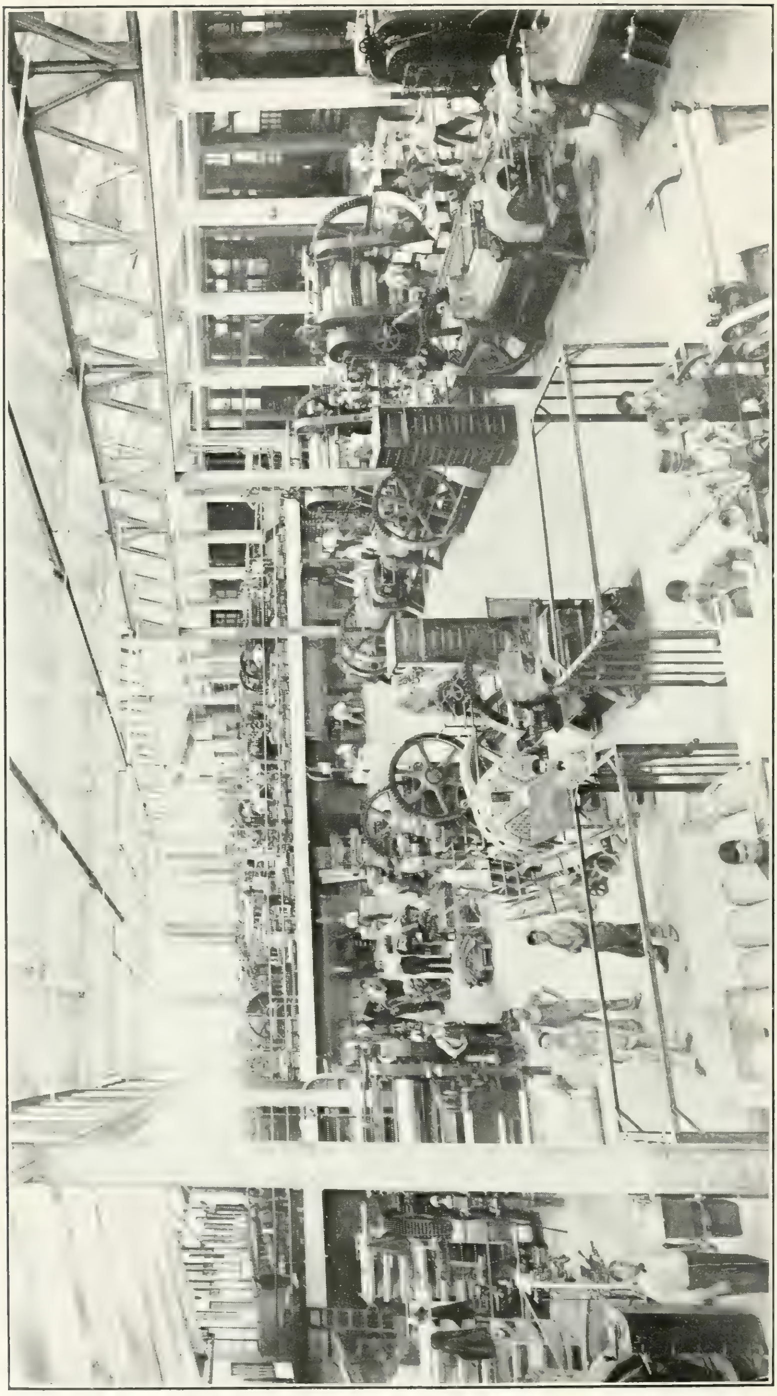
To obtain correct specifications, all mention of chemical composition should be eliminated. Based primarily upon the fundamental principle that the percentage of crude rubber cannot be positively determined and the influence of the different mineral matters, etc., are known to the rubber manufacturer chiefly, the specification of a percentage of pure Fine Para is at best uncertain. Strictly speaking, pure Fine Para is the crude rubber obtained in the smoking process on the Amazon and tributaries. The term "Pure Fine Para" should include not only the rubber obtained from the Amazon, but also rubber from the tree Hevea-brasiliensis, made anywhere in the world. The term "Para" is derived from the town Para, but practically applies to rubber from the foregoing tree. In view of the fact that Para rubber, Congo rubber, etc., differ from each other in their crude state by the percentage of acetone usually found, chemists have been in the habit of stating that pure Fine Para is present when the acetone extract is low and not present when it is high. Here specifications are uncertain and testing methods unreliable since this test does not prove nor disprove the presence of any grade of rubber and much depends upon the analyst's judgment.

The only determination today made is that of rubber hydrocarbon, and since this varies in properties, tensile strength, aging properties, etc., it is useless to attempt to specify it.

In the same way the specification of sulphur of mineral matter or any other kind of added material is not warranted. Any attempts by buyers or consumers to make specifications covering these matters would be, at best, uncertain. The best way, therefore, is to specify that the article must comply with certain physical requirements and leave it wholly to the manufacturer to decide on what chemical composition will meet these specifications.

Physical Properties.

The buyer can establish physical properties and lay out tests to determine them which will show the value of the article for his purpose. They should be made severe, but well balanced. Tensile strength, elongation and recovery should be specified in terms that will give the highest possible value as required for the article in question.



Factory Mill and Calender Room.

You buy vanadium steel, high carbon steel, bronze, etc., not because of their respective composition, but because that composition has been shown to have certain valuable properties. It is, after all, the properties that we buy.

Service Tests.

Comparative service and aging tests should be required. The objection has been frequently raised and probably will be raised by some of you that it is a difficult matter to place, under any conditions, an article and then age it so that in a short time it is possible to deduce the effects of long use.

However, granted that the difficulty is great, it is not insurmountable. What is desired is not so much that the rubber be completely used up in a service test as that the rate of deterioration be determined. Given then the rate of deterioration of hose, the quality of which in service is well known, and it is perfectly possible to predict from a curve the comparative aging value of the unknown.

If consumer and producer will co-operate, these service tests can be developed and to the advantage of all concerned.

VI. Statistics of the Rubber Industry:—

I wish to acknowledge my obligation to Schidrowitz's recent work on rubber for most of the statistics of this lecture. It is very difficult to arrive at exact figures either of production or consumption.

The total production of crude rubber for the year ending June, 1910, was probably between 85,000 and 90,000 tons. It is estimated that in the present year, 1911, when the figures are in, they will show production about as follows:

	Per Cent.	Tons.
Brazil, Peru and Bolivia.....	46.5	40,000 to 41,000
Other South American states, Mexico and Central America	17.5	15,000 to 17,000
Africa	17.5	15,000 to 17,000
Ceylon, Malay, Java, Sumatra and Borneo............	16.2	14,000 to 15,000
Miscellaneous	2.3	2,000 to 3,000
Total for 1911.........	100.0	86,000 to 93,000

I. THE UNITED STATES.

Imports of crude rubber (official statement for the fiscal year ending June 30):

	1907-8 Pounds.	1908-9 Pounds.	1909-10 Pounds.
Total	62,233,160	88,359,895	101,044,681
Import value	$36,613,185	$61,709,723	$101,078,825
Average per pound	58.8 cents	69.8 cents	$1.00

Net Imports (*Retained for Consumption*).

	1907-8 Pounds.	1908-9 Pounds.	1909-10 Pounds.
Imports	62,233,160	88,359,895	101,044,681
Exports	4,110,667	3,791,961	6,492,947
Net Imports..	58,122,493	84,567,934	94,551,734
Per cent.....	93.5	95.6	93.7

OTHER UNITED STATES IMPORTS.

	1907-8 Pounds.	1908-9 Pounds.	1909-10 Pounds.
Balata	584,552	1,157,018	399,003
Gutta Percha	188,610	255,559	784,501
Waste rubber	16,331,033	20,497,695	37,364,671
Gutta-jelutong	22,803,303	24,826,296	52,392,444

EXPORTS AND IMPORTS OF MANUFACTURED GOODS.

Exports.

Articles.	Value.
Belting, packing and hose	$1,960,825
Boots and shoes	1,984,739
Other goods	5,115,331
Total	$9,060,895

Imports.

Value	$1,154,347

II. THE UNITED KINGDOM—CRUDE RUBBER.

	Imports.		Re-Exports.		Retained for Consumption.	
	Quantity, Pounds.	Value, Dollars.	Quantity, Pounds.	Value, Dollars.	Quantity, Pounds.	Value, Dollars.
1910	87,696,800	126,831,362	46,787,200	72,185,886	40,909,600	54,645,476
1909	70,006,200	68,711,672	39,792,400	44,313,888	30,223,800	24,397,783
1904—8 (Average)	58,778,100	45,212,531	33,412,900	28,472,252	25,365,200	16,740,280
1907	66,729,400	53,142,929	....	....	....	....

EXPORTS AND IMPORTS OF MANUFACTURED GOODS. 1909 AND 1910.

	Exports, Value. 1909	Exports, Value. 1910	Imports Value. 1910	Exports Value. 1910
Boots and shoes	$ 999,546	$ 931,604	$ 943,369	$73,269
Waterproof garments	1,434,594	2,424,047	35 852	5,229
Miscellaneous goods	7,659,360	8,830,280	—not stated—	
Cables (other than telegraph and telephone)	1,406,202	2,168,431	822,307	60,672
Telegraph and telephone cables	3,616,520	11,085,223	1,308,642	80,977
Totals	$15,116,223	$25,470,482	....	......

III. GERMANY—CRUDE RUBBER.

	1909—Pounds.	1910—Pounds.
Imports	31,000,000	37,400,000
Re-Exports	8,000,000	9,800,000
Balance retained	23,000,000	27,600,000

MANUFACTURED GOODS, EXPORTS, 1910 (*Chief Articles Only*).

	Quantity, Pounds.	Value, Dollars.
General soft rubber goods	1,730,600	2,002,320
Ebonite	546,800	425,736
Proofed goods	1,289,400	1,440,747
Cables (lighting, aerial, telegraph, etc.)	5,138,000	1,529,685
Submarine, etc., cables	65,356,000	11,514,089

IV. FRANCE. CRUDE RUBBER AND GUTTA.

	1909—Pounds.	1910—Pounds.
Imports	26,368,000	33,700,000
Re-Exports	16,486,000	24,434,000
Balance retained	9,882,000	9,266,000

RUBBER PRICES.

The Wall Street Journal, under date of Nov. 24, 1911, gives an interesting article on the range of rubber prices during the past 22 years:

Year.	High.	Low.	Changes.
1911	$1.70	$0.98	$0.72
1910	3.10	1.44	1.66
1909	2.22	1.26	.96
1908	1.30	.69	.61
1907	1.27	.82	.45
1906	1.30	1.24	.06
1905	1.40	1.23	.17
1904	1.33	1.00	.33
1903	1.13	.91	.22
1902	.98	.81	.17
1901	.87	.66	.21
1900	1.16	1.00	.16
1899	1.16	1.04	.12
1898	1.10	.90	.20
1897	.91	.84	.07
1896	.91	.78	.13
1895	.84	.74	.10
1894	.74	.66	.08
1893	.84	.74	.10
1892	.68	.60	.08
1891	.87	.66	.21
1890	1.00	.72	.28

Discussion

H. E. Smith:—

In the judgment of rubber goods we find chemical analysis, physical tests and actual service all valuable. Actual service is the final criterion of values, but in the inspection of shipments of material the testing engineer usually may not take the time required for actual service trials. For example, a concrete structure will last many years, yet the cement in it must be tested within 28 days or less.

"Accelerated" service tests may sometimes be made, but there is danger that, if the acceleration is sufficient to be valuable, the conditions of the test may be made so much more drastic than normal service that erroneous results are obtained. Chemical analysis and physical tests may, therefore, be the only means of judgment available. Obviously the decision must be based on the application of really instructive methods of test and the correct interpretation of results as well as a thorough knowledge of actual service conditions.

Specifications are always useful if they can be made to de-

scribe the material accurately and in such manner that shipments can be checked by them. A specification for hose, which states simply that the hose must have certain dimensions and be composed of tube, fabric and cover, "each of the best of its kind for the purpose", is not very valuable. Satisfactory specifications are not always easy to write and require much careful study. Many of those now in use for rubber hose are unquestionably faulty or insufficient.

H. M. Foote, Jr.:—

Mr. President and members of the Cleveland Engineering Society: There is very little that I can add to Dr. Geer's lecture on "Rubber", as he has covered the subject in such a general, but comprehensive manner. But as engineers, I desire to call your attention to several technicalities in the design of rubber bumpers and other molded rubber goods.

Persons unfamiliar with the manufacture of molded rubber goods seem to be under the false impression that the unvulcanized rubber is melted in a crucible, or other retort, and is poured into a mold. Very often a wooden pattern is furnished for this purpose.

Molds for rubber are made of cast iron, steel, or white metal. Two plates, or sometimes three, as the case may require, are planed to the desired thickness, and in these plates a number of cavities, depending on the number of rubbers to be produced per heat, are machined. All of these cavities must be exactly alike and of the same shape as the rubber to be produced, a little allowance being made for the shrinkage of the rubber. Each cavity is, therefore, a negative of the molded article. Most of these cavities are machined on a drill press. Some are easier made on a die sinker, boring mill, or milling machine.

It is perfectly obvious then that the molds easiest and, therefore, cheapest to make are those that can be roughed out with a drill, and finished with a formed tool. Sharp corners then should be generally dispensed with where possible. The article should also be of such shape that it will draw from the mold after it has been vulcanized in it. To do so, it is best to avoid beads or recesses where possible.

Holes in bumpers, etc., are invariably molded, much the same as a hole is cored in an iron casting with the exception that instead of a sand core being used, a steel pin, the same shape as the hole to be made, is permanently fastened into one mold plate and made to register in the other plate. It is obvious that all holes should be round rather than rectangular or oblong, and of such shape that the pin may be made on a lathe or screw machine.

Trade marks, patent dates, etc., are easiest made with raised letters on the rubber, since they can be stamped into the mold with a steel stamp. It is also easier to put such marks on a flat rather than a curved surface.

White metal molds are only used where it is too difficult to make a cavity in cast iron or steel, or where a great amount of bench work would be required. In such a case a steel matrix is

made the exact shape of the rubber, allowance being made for the shrinkage of the white metal and the rubber. A frame is then clamped to the matrix, and molten white metal poured into it, thus producing a cavity of the desired shape.

After the mold has been completed, the raw or unvulcanized rubber is formed to approximately the desired shape, and is placed in the mold. The mold is then placed in a press which has two or more steam-heated plates, and the press plates are forced into close contact with the mold, usually by hydraulic pressure. The unvulcanized rubber, being very soft and plastic under heat, flows into all parts of the mold cavity. The mold is allowed to remain in the press a sufficient length of time to thoroughly vulcanize the rubber. The rubber is then taken out of the mold, and the flash, or overflow, trimmed off, after which it is ready for use.

In regard to specifications for rubber hose, etc., I think that it would be advisable for the manufacturers of rubber goods to form a bureau for the standardization of specifiations. The manufacturer is of necessity more familiar with the numerous elements that enter into the production of rubber goods, and if furnished the necessary data, should be in a better position to design a hose or belt to meet a certain specific requirement than the purchaser. The same as an engine builder or architect is more capable of designing an engine or building and specifying what material should enter into its construction than the purchaser of the engine or building. The consumer should, however, be given a reasonable guarantee that the rubber, duck, etc., used in the construction of his goods meets certain physical tests and chemical analysis. It is to the manufacturer's interest to produce goods that will wear the longest and give the best service for the money, and the best results can be attained only when the manufacturer has the complete confidence of the consumer.

Society Notes

MINUTES OF MEETINGS.

Nov. 14, 1911.—Regular meeting called to order by President Roberts at 7:45 P. M. Present, about 150 members and guests.

Minutes of meetings Oct. 10 and 24 read and approved.

Applications for membership were received and passed to letter ballot as follows:

For active members:—

ARTHUR S. HECKER HARRY D. HUGHES
GEORGE W. HEINKEL CARL U. NORTH
HARRY L. PORTER

For associate members:—

THOMAS F. BECHTEL JOHN R. BENTLEY ALBERT E. DERBY

For corresponding member:—

RAYMOND G. DE FREES

Teller's report showed the election of the entire membership ballot. (See list in minutes, Oct. 10, 1911.)

A letter was read from the Cleveland Section of the American Chemical Society, requesting that a committee be appointed by the Cleveland Engineering Society to act with a similar committee from the Chemical Society to consider the question of the water supply for Cleveland, and its improvement. President Roberts announced that he would appoint such a committee in a few days.

The program consisted of a series of papers on "The Purification of Water", presented by R. Winthrop Pratt, special sanitary engineer, city of Cleveland; Dr. R. G. Perkins, Western Reserve Medical College, Cleveland; R. M. Leggett, the National Air Purifying Co., Ann Arbor, Mich. (Paper read by R. H. Klauder); D. D. Vincent, the Electra Pure Water Co., Cleveland. The following phases of the subject were discussed: "Purification by Filtration", Mr. Pratt; "Purification by Chemicals and Interpretation of Water Analyses", Dr. Perkins; "Purification by Ozone", Mr. Leggett; "Purification by Electricity", Mr. Vincent.

Following the presentation of the papers, a lively general discussion ensued.

A hearty vote of thanks was tendered the speakers of the evening.

Adjourned.

F. W. BALLARD,
Secretary.

Nov. 28, 1911.—Special meeting called to order by President Roberts at 7:45 P. M. Present, about 80 members and guests.

There being no business to come before the meeting, President Roberts introduced Dr. William C. Geer, of the B. F. Goodrich Co., Akron, O., who presented an interesting paper on "Rubber", showing a number of stereopticon views illustrating rubber plantations, methods of manufacture, etc.

During the general discussion, many questions were asked, which were answered by Dr. Geer.

A vote of thanks was tendered the speaker.

Adjourned.

F. W. BALLARD,
Secretary.

Dec. 12, 1911.—Regular meeting called to order by Vice President Fernald at 7:45 P. M. Present, about 95 members and guests.

Minutes of meetings Nov. 14 and 28 read and approved.

Report of the Tellers was read, showing the election of the entire membership ballot. (List of names in minutes of Nov. 14, 1911.)

Applications for membership were received and passed to letter ballot as follows:

For active members:—

George L. Craig	Levi E. Jennings
Richard Fleming	Arthur E. Schwemler
John W. Holt	James G. Sterling

For associate members:—

Clifford M. Alexander	Arthur J. Hudson
Russell A. Bogardus	Allison J. Thompson

An invitation was read from the American Institute of Electrical Engineers, to the Cleveland Engineering Society, requesting that as many of the Engineering Society members as possible be present at the American Institute meeting at 8:00 P. M., Monday, Dec. 18, 1911, at the Chamber of Commerce Library, to hear an address by Dr. A. A. Hammerschlag, director of the Carnegie Technical Schools, Pittsburgh, Pa., on the subject "Engineering Education".

The address of the evening was delivered by Mr. Norman Macbeth, illuminating engineer of the Westinghouse Lamp Co., Bloomfield, N. J., on the subject "Applications of Illuminating Engineering in Store and Factory". A number of lantern slides were used as illustrations of proper and improper methods of lighting.

A lively discussion followed, in which the following persons participated: Messrs. Luckish, Dates, Harrison and Mott. Also, a number of questions were asked, all of which were ably answered by Mr. Macbeth.

A vote of thanks was tendered the speaker.

Adjourned.

G. S Black,
Acting Secretary.

Jan. 9, 1912.—Regular meeting called to order by President Roberts at 7:45 P. M. Present, 65 members and guests.

Minutes of meeting Dec. 12, 1911, read and approved.

Report of the Tellers showed the election of the entire membership ballot. (List of names in minutes of Dec. 12, 1911.)

Applications for membership were received and passed to letter ballot as follows:

For active members:—

Harry A. Fulton   Linde V. Gaylord   Harry E. Weeks

For associate membership:—

James Connelly

The President then introduced the speaker, Mr. C. E. Denney, signal engineer, L. S. & M. S. R. R. Co., who presented an illustrated paper on the subject "Railway Signaling". The discussion following was participated in by Messrs. Bates, Roberts, Edw. Snider and W. M. Ray.

A vote of thanks was tendered the speaker.

Adjourned.

G. S. Black,
Acting Secretary.

Jan. 24, 1912.—Special meeting of the Cleveland Engineering Society and the Ohio Engineering Society in the Assembly Hall of the Hollenden Hotel, Cleveland. Present, about 200.

Meeting called to order by President Lindsey, of the Ohio Society, at 8:00 P. M. The address by W. L. Page, scheduled for the afternoon session, had been postponed and was first on the program for the evening session.

President Roberts of the Cleveland Society then took the chair and introduced Mr. R. C. Beardsley, who presented an illustrated paper on "The Design and Construction of Dams", with special reference to recent failures.

This paper was followed by a lively discussion participated in by Messrs. A. J. Himes, E. G. Bradbury, S. W. Emerson, G. H. Tinker and A. W. Ray.

Meeting adjourned.

G. S. B[illegible]
Acting Secretary.

LIBRARY.

The following are some of the recent additions to the library:

Transactions of the American Institute of Electrical Engineers, Vols. 10 to 29, inclusive, donated by C. W. WASON.

The Plums of New York, HEDRICK, donated by W. BEAHAN.

International Railway Congress Association, Eighth Session, Vol. I.

Proceedings American Society for Testing Materials, Vol. II.

Proceedings Institute of Mechanical Engineers, 1911, Parts 1 and 2.

Students of the metallurgy of steel should read *Two Lectures on Steel*, by PROF. W. ROSENHAIN, in *Proceedings Institute of Mechanical Engineers*, 1911, and *Structure of Steel*, by PROF. H. M. HOWE, in *Proceedings American Society for Testing Materials*, Vol. II.

G. H. TINKER,
Librarian.

EMPLOYMENT BULLETIN

This department is for the use of members desiring positions or requiring engineering services; it is under the personal direction of the secretary, who is anxious to increase its value to the members. Therefore, if you are in need of engineering help, or desire to secure a position, do not hesitate to call on the department for assistance.

All information is handled confidentially.

MEN AVAILABLE.

No. 14A. Graduate civil engineer, Ohio State University, desires position as inspector, transitman or draftsman; two years' experience consisting of designing, concrete structures, inspection of concrete and steel bridges and also city surveying.

No. 15A. Mechanical engineer, Case School, B. S. Some experience with electrical machinery, ore handling machinery, etc.

No. 16A. Mechanical engineer, University of Pennsylvania, 1907, M. E. Machine shop, construction, power plant and some sales experience.

No. 17A. Mechanical engineer; experience covers varied mechanical lines, car design and signal work, construction in concrete and steel, and testing; special training in patent investigations, shop methods and cost keeping. Desires position as mechanical engineer or assistant to superintendent.

No. 18A. Mechanical engineer, Massachusetts Institute of Technology; thorough machine shop training; desires position as superintendent of mechanical shop.

No. 19A. Structural draftsman; seven years' experience, one year of field work (erecting); desires position as draftsman or field man.

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Railway Signaling

By C. E. Denney

I have assumed that your engineering study and experience has been along lines other than signaling; in fact, I agreed to talk only after being assured by your Secretary that none of the members will know anything about signals. Did he mean when you came here tonight or when you go home?

First—The Reason for Signals on a Railroad

A signal is generally regarded as a device for indicating "Stop" to approaching trains. Modern signaling, however, is designed and installed primarily to keep trains running rather than to stop them. Trains are required to stop before proceeding over a non-interlocked railroad crossing. After an interlocking is installed, they proceed at full speed over the crossing, unless a conflicting train movement is being made or the track and signals are arranged for it to be made. The tower man in charge of the interlocking machine is enabled by schedules and advance information of the approach of trains to arrange the track and signals for train movements with a minimum delay.

Automatic block signals likewise are installed to permit a number of trains to be run at speed safely. The function of signals may, therefore, be defined as a means of reducing the number of stops required before signals were installed, or as has aptly been said "saving seconds safely".

It is the intent of the talk this evening to describe signaling from an operating, rather than an engineering standpoint; in other words, to describe the methods of governing movements of trains by signals rather than the design and installation of the apparatus, treating the subject under the two general headings of block signaling and interlocking.

Block Signals.—It is apparent that the safe operation of trains on the same track requires that they shall be separated by an interval of time or space. The time interval is safe if trains are operated at approximately uniform speed and properly and promptly protected when stopped, and it is now in use on some railways or portions of railways, usually where comparatively slow speed freight trains only are operated.

The operation of both high speed first class and low speed lower class trains renders the time interval between trains inadequate, and the space interval blocking has, therefore, come into general use.

Block signaling of this class may be divided into three types, namely: Manual, controlled manual and automatic.

The Manual Block System or telegraph block system, as it is sometimes known, is a system in which the block signals at a block station are operated by an attendant on information con-

veyed to him from the other block stations by telegraph, telephone, or electric bells, the telephone now coming into general use.

The Controlled Manual Block System is a manual block system, in which the signal apparatus at one end of the block is electrically locked with that at the other end in such a way as to display a proceed signal to permit a train to enter the section only by the co-operation of the men located at the stations at

PLATE 1

either end of the block. The control features in the manual block system are installed as a check on the men, the rules for the operation of the manual block and controlled manual block being practically the same.

Given a section of road, for example an operating division, on which train movements are controlled by one dispatcher, either single or double track, the number and length of blocks into which the division is divided for manual or controlled manual

operation is determined from a study of the number and class of train movements, grades, locations of passing sidings (usually at cities or towns), junction points, etc.

As the number of block stations is determined by the maximum amount of business to be handled at any one time, it therefore reasonably follows that it is not necessary to have all offices open continuously, and the heaviest traffic is handled usually during the working day. Certain block stations are open continuously, others for a portion of the day, two or more blocks being temporarily combined and operated as one block between the offices either side of the closed office or offices.

At each block office, a signal is erected about opposite or 200 or 300 feet beyond the office, controlled by a lever in the block office. Plate 1 shows a two-position block signal, the arm in the horizontal position indicating "Stop" on account of the block occupied or train orders, and in the diagonal position, as shown indicating "Proceed".

It is the practice on some roads to keep the signal in the stop position until it is to be cleared for an approaching train, and on others to keep it in the proceed position until it is to be put to the stop position for a train. The former is termed normally stop, and the latter normally clear system. Each system has its advocates, but the results accomplished are the same.

If a second train is not permitted to enter a block occupied by a preceding train going in the same direction, the system is termed absolute block.

If a train is permitted to enter an occupied block under certain rules and restrictions, as to class of train, the system is termed permissive block. On many roads, permissive blocking is in effect, second and lower class trains being allowed to follow other than first class trains into the block, the train being notified that a preceding train has not cleared the block, or a time interval is maintained between the second and lower class trains. First class and all passenger trains are not permitted to enter an occupied block or to be followed into a block.

The number of block offices for handling heavy traffic makes the expense of operation almost prohibitive. Three men are necessary to operate an office open more than 18 hours since the so-called "Hours of Service Law" has been in effect. Where heavy traffic is being handled, the expense is very high on account of the number of men employed, block sections of not more than three miles being necessary in some locations.

The first block signal system in America was installed between Kensington, Pa., and Trenton, N. J., in 1863 or 1864, the space interval having been put into effect after a disastrous rear end collision of east bound freight trains at night, carrying soldiers from the seat of the war to New York and New England. In 1872, when the Pennsylvania railroad took control of these lines, a length of 90 miles was being worked by the block system, the block signals consisting of banners in boxes supported on posts, and red flannel banners were dropped in front of a white surface or white light for the stop indication.

Statement as of Jan. 1, 1912, shows that approximately 45,500

miles of single track and 8,429 miles of road of two or more tracks are operated by the manual or controlled manual block system.

The Automatic Block System may be defined as a block system, in which the signals are worked by power without an attendant, the power being controlled by the passage of a train into, through and out of the block section. The kinds of power used are electro-magnets, actuated by primary or storage batteries, weights or clock work, compressed air, carbonic acid gas, and electric motors operated by primary or storage batteries, or on electric and on some steam lines by alternating current.

After stopping at an automatic signal indicating stop, a train is allowed to proceed into the block, expecting to find a train, broken rail, open switch or some other obstruction in the block. The block lengths usually vary on steam roads from 3,000 feet to three miles. It is the exception, however, to install blocks of more than one and one-half miles in length.

Automatic signals were invented in America and have been developed on American railways. The track circuit, which consists of a battery, located at one end of the block, one pole of the battery being connected to either rail, and a relay, usually of about 4 ohms resistance, located at the other end of the block, the current from the battery being carried through the rails to the terminals of the electro-magnet of the relay, controlling the movement of an armature, which carries a contact for the control of the signal circuits. A train, car or open switch sets a signal to indicate "Stop" by short circuiting the current flowing through the rails of the track. The track circuit was invented in 1879, and was introduced on 10 miles of the Fitchburg railway, near Boston, and from that time automatic signals have made steady, though rather slow progress, the most extensive installations having all been made during the last 15 years.

The report as of Jan. 1, this year, shows approximately 9,500 miles of single track and 10,500 miles of road of two or more tracks, a total of 20,000 miles of road protected by this system.

Automatic signal installations are made not entirely in the interests of safety of operation, although this naturally follows. They provide a means for securing the maximum capacity of track consistent with the speed at which trains are to be operated, and bring about economies when the traffic on a road becomes sufficient to warrant the installation. I feel safe in saying that on some busy roads, the interest on the investment, depreciation of the apparatus, and cost of maintenance and operation is entirely saved in the actual cost of handling trains. The protection afforded, therefore, is practically secured without cost. I would not wish to be misunderstood as meaning that money can be saved on all railroads by installing automatic signals, as they are not warranted by light traffic which can be satisfactorily protected by the manual block system with comparatively long blocks.

The indications displayed by the signals, and the fundamental methods of control on single track and double track are the same. It is, however, necessary to interconnect the signals on single track so that following and opposing movements are properly

protected, while on double track following movements only are provided for, movements against the current of traffic being handled by train orders.

Advance Information.—The running of trains at high speed requires that the engine man shall be given advance information indicating that the next signal is at stop if the high speed is to be

PLATE 2

maintained to the known location of the stop signal, especially if weather conditions are unfavorable and a smooth "service stop" is to be made. This advance information is indicated by what is termed a distant signal or caution signal, and the distance at which this signal is placed from the home signal is determined by the maximum speed of trains, brake efficiency, and grades. This distance has been materially increased within the past 15

years, and the distant signals for high speed tracks are now usually located from one-half to one mile from the home signals.

Plate 2 shows two automatic signals for two tracks in the same direction, both signals indicating "Stop". The top arm on each pole is the home signal and in the horizontal position indicates "Stop, block occupied". The lower arms are the distant signals for the home signals on the poles in advance, and move

PLATE 3

to the diagonal position only when the home signal above it, and the next signal in advance are in the diagonal or proceed position.

The least favorable indication of the automatic signal is "Stop", as shown by the last plate. A more favorable indication is "Proceed, prepared to stop at next signal", as indicated by the signal on the right. Plate 3. The most favorable indication is "Proceed" (both arms inclined), as shown by the signal on the left.

All circuits for automatic signals and insofar as possible for all signals, are arranged on the normally closed circuit principle, and the signals are restored to the normal stop or caution position by gravity. You will understand that this is essential to provide

PERMISSIVE SIGNALS

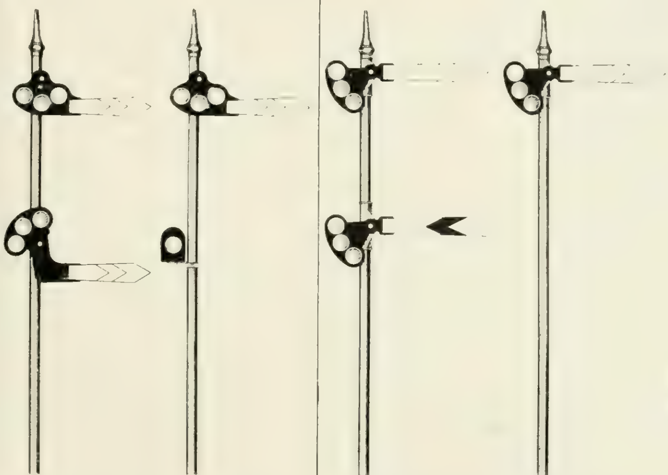

FIG. 20 **FIG. 21**
(UPPER QUADRANT)

LIGHTS, DIAGONAL:
UPPER---RED.
LOWER---RED.

FIG. 22 **FIG. 23**
(LOWER QUADRANT)

LIGHTS:
UPPER--RED.
LOWER--GREEN

LIGHT--RED.

INDICATION---STOP. PROCEED WITH CAUTION.

PLATE 4 (1-A)

that a break in the circuit or the failure of the battery will cause the signal to indicate "Stop" or "Caution", and it can be made to indicate "Proceed" only when the circuits are complete and the block unoccupied and unobstructed.

The signals shown on the screen up to this time have been of the lower-quadrant type and are in general use. You will note that the pivot for the semaphore casting is on the right, and the casting, when the signal is clear, moves above and the blade below

PERMISSIVE SIGNALS

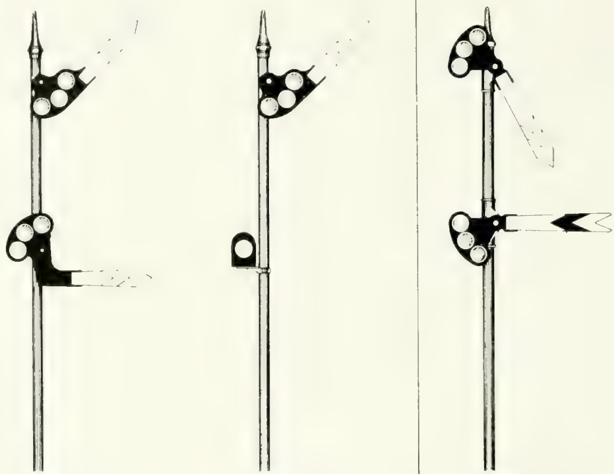

FIG. 24 FIG. 25
(UPPER QUADRANT)

LIGHTS, DIAGONAL:
UPPER---GREEN.
LOWER---RED.

FIG. 26
(LOWER QUADRANT)

LIGHTS:
UPPER---WHITE.
LOWER---GREEN.

INDICATION---PROCEED, PREPARE TO STOP AT NEXT SIGNAL.

PLATE 4 (1-B)

the horizontal position. The torque tending to return the signal to the stop position is, therefore, dependent upon the difference in the weight and the distribution of metal in the semaphore casting and the weight, length and shape of the casting and blade to the right of the pivot.

This torque is not exactly uniform, as the arm moves through the arc, but in the most approved designs of castings, it is greatest when the signal is in the full proceed position, from which it must overcome the inertia of the parts and begin its movement to the normal position.

PERMISSIVE SIGNALS

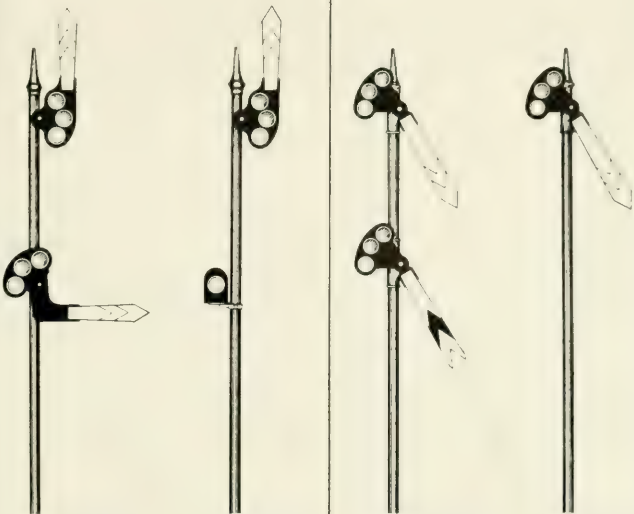

FIG.27 FIG.28
(UPPER QUADRANT)

LIGHTS, DIAGONAL:
UPPER --- WHITE.
LOWER --- RED.

FIG.29 FIG.30
(LOWER QUADRANT)

LIGHTS:
UPPER -- WHITE.
LOWER -- WHITE.

LIGHT - WHITE.

INDICATION --- PROCEED.

PLATE 4 (2-A)

The difference in the weight of the casting on the left and the casting and arm on the right of the pivot is decreased by adding weight on the blade, as would occur from the collection of snow and ice on the signal, and it is, therefore, necessary to

provide a casting of weight sufficient to counterbalance the combined weight of blade and ice accumulation.

The amount of material used in manufacture and current required for operation has been reduced during the past few

PERMISSIVE SIGNAL

LIGHTS, DIAGONAL:
UPPER---GREEN.
LOWER---WHITE.
INDICATION---PROCEED, PREPARE TO PASS NEXT SIGNAL AT LIMITED SPEED.

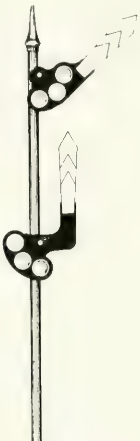

FIG. 31

PLATE 4 (2-B)

years by the design of upper-quadrant signals, as shown by Figs. 20, 21, 24 and 25, on the screen. The pivot in the casting is to the left of the center of gravity of the casting, and when the signal is operated, the complete blade and casting moves upward

and to the right. Any increase in the weight from sleet or any other cause, therefore, adds to the force tending to return the signal to the horizontal stop position.

The remarks which have been made in regard to the closed circuit principle and power signals being restored to the stop position by gravity apply equally to block signals and interlocked signals.

The plate now on the screen and the one immediately to follow show the corresponding upper and lower quadrant signal indications and are designed so that they can be used in the same territory without conflict. This is necessary if any change is to be made from lower-quadrant system previously installed to the upper-quadrant system, and you will note that the horizontal position indicates "Stop" in either type.

Fig. 25 shows the signal arm inclined at 45 degrees in the upper-quadrant and the indication to the engine man is the same as Fig. 26 (lower-quadrant) top arm inclined, lower arm at caution, previously described as "Proceed, prepared to stop at next signal".

Fig. 28 shows upper-quadrant signal in the vertical position, and the indication is the same as Fig. 29, both arms of the two-arm home and distant signal inclined below the horizontal, indicating "Proceed".

In addition to the mechanical advantages stated for the upper-quadrant signal, you will note that the use of this signal in three positions (horizontal, 45 degrees and vertical) gives the information which is conveyed by operating the two arms of the two-position lower-quadrant type. Three-position lower-quadrant signals are also in service on some roads, but it is safe to say that a majority of the installations to be made in the future will be three-position upper-quadrant type, as it combines all of the advantages.

Interlocking.—Block signaling is for the protection of trains moving on the same track. If it is necessary to cross another track on which conflicting movements may be made, or if it is desired to move from one track to another, without first coming to a stop, it is necessary to install an interlocking plant to operate the derails, switches and signal protecting the crossing or junction points.

Interlockings are of two general types, namely, mechanically and power-operated. It has recently been found desirable in the interest of economy to design an electro-mechanical machine, in which the switches are handled mechanically and the signals by power on account of some signals being located too far from the tower for safe mechanical operation, and because the home signal of an interlocking operates automatically from the 45-degree to the 90-degree position, as shown for permissive signals, when the next automatic signal in advance indicates that the second block is clear.

Plates 5 and 6 show an electro-mechanical machine which embodies the principles of operation of both mechanical and power machines.

The building from which the machine is operated is usually

PLATE 5

called the interlocking tower. The levers are placed in the second story of the building in order that the view of the leverman may not be obstructed by passing trains.

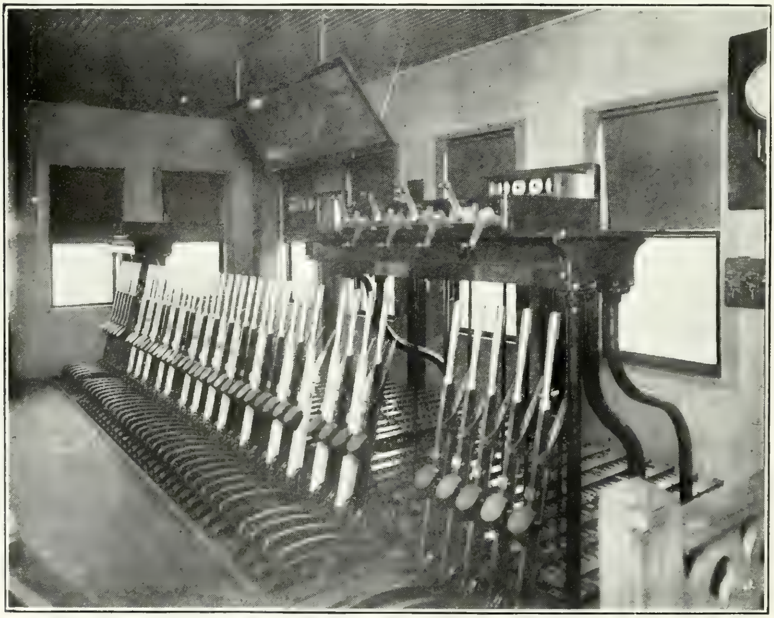

PLATE 6

Plate 7 shows a view of the interior of the tower, the switches, derails and movable point frogs being moved and locked by operating the long mechanical levers, the power signals being operated by the movement of the short levers at the ends of the machine. All levers are interconnected by the locking to require a predetermined order of operating the levers to prevent signals for conflicting movements being operated and so far as practicable to require the track to be arranged so that a train disregarding a signal cannot collide with a train using an authorized route.

Plate 8 shows the rear of the machine. The locking is in the locking bed, extending from end to end of the machine.

The connections from the upper story of the tower to the

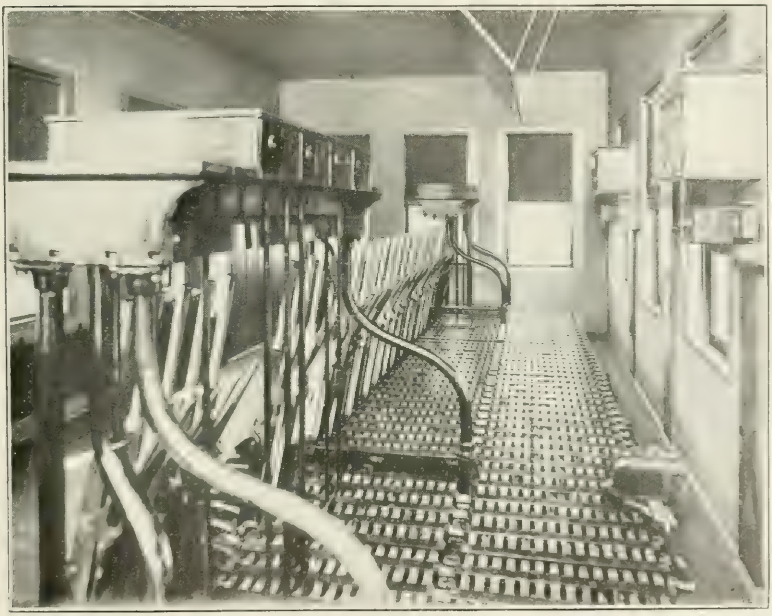

PLATE 7

lead out at the base of the lower story is arranged as shown on the plate, the construction, as shown, being entirely fireproof.

The movement of the lever is transmitted to the connections on the ground in front of the tower through the shafts and arms, as shown on the plate.

The connection to the switch is made of 1-inch heavy pipe, supported on carriers, spaced about 7 feet, and is attached to the switch point, as shown. To insure that the switch has been completely thrown to the new position before the signal governing the movement over it can be cleared, a lock (which can be satisfactorily maintained to detect an opening of ⅛ inch of the switch point) is operated by a second lever interconnected with the first through the locking; and to protect against the switch being un-

locked while the train is passing over it, a detector bar normally set against and below the top of the rail is operated above the rail and returned to its normal position by the lock lever.

Movements with the established current of traffic are governed by high signals located over or to the right of the track governed, the signal shown being of the upper-quadrant type, and three arms are displayed for each track.

PLATE 8

Movements against the current of traffic on main tracks or on side tracks are governed by dwarf signals placed between the tracks, the signal shown being of the two-position, upper-quadrant type.

Levers operating switches, derails or movable point frogs by power (instead of mechanically, as shown on the plates); and

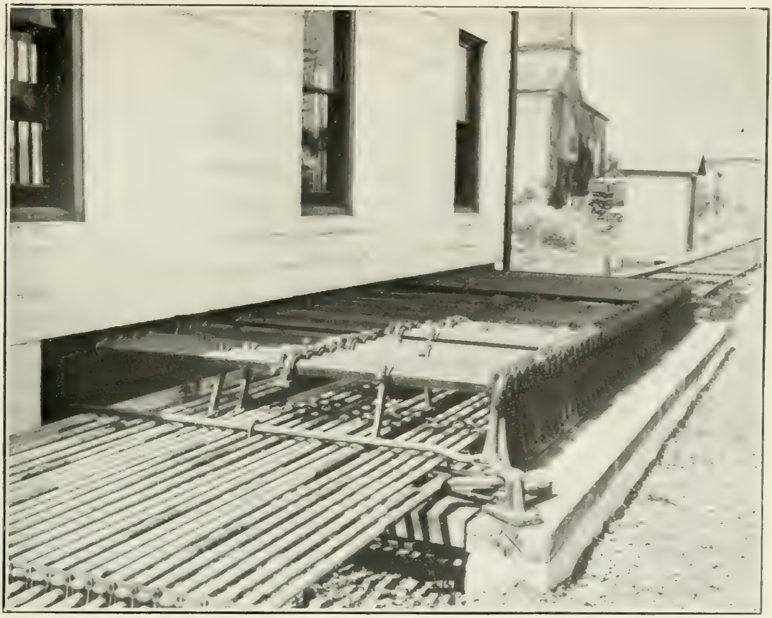

PLATE 9

those operating power signals, as shown, are provided with an indication lock, which will allow the lever to be fully restored to its normal position and other levers correspondingly released

PLATE 10

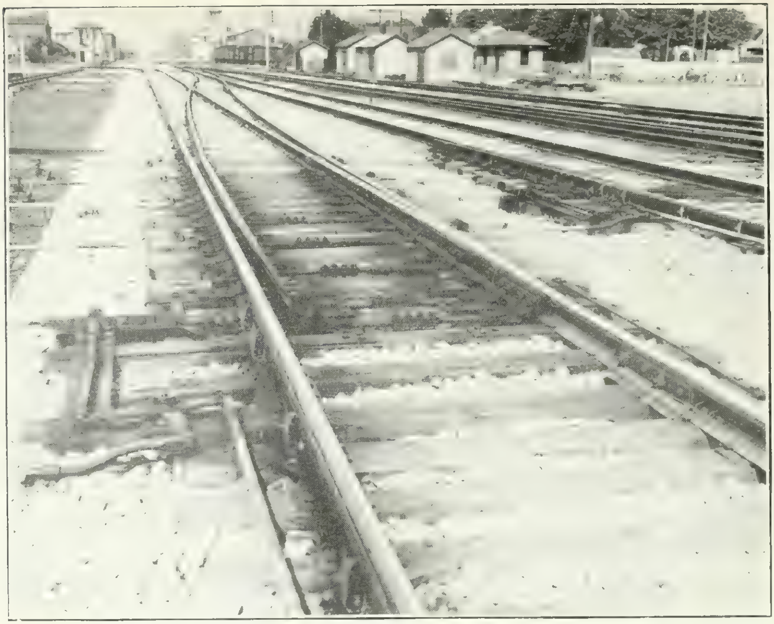

PLATE 11

through the locking only when the switches or signals have assumed a position corresponding with the position of the lever. Indication locks for the signals shown are operated by electro-

PLATE 12

PLATE 13

magnets placed over the levers which are energized only when the signals are in the full stop position.

The interlocking described is installed for the protection of a single-track crossing with a four-track road, and to operate a system of cross-overs so that trains may be diverted from one track to another without stopping. A general idea of the track and signal arrangement is shown on the screen.

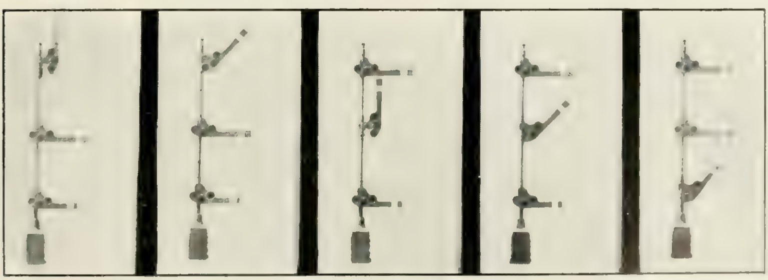

PLATE 14

The indication of an automatic signal is displayed by one blade, as only one route is governed. The three-arm upper-quadrant signal shown on the screen is installed to provide indications for proceeding on a through normal speed route, diverging to a medium speed route, or diverging to a low speed route. Each arm operates in three positions, and the two upper arms in addition to indicating the speed at which a train may pass a signal

with the current of traffic, indicates the position of the next signal in advance. The bottom arm is shown in only two positions on the plate, although it is used to give three indications. It is operated principally for movements to occupied side tracks, to tracks against the current of traffic.

The top arm governs movements on the normal speed route; in the 90-degree position indicates "Proceed"; and in the 45-degree position, as shown, indicates "Proceed, prepared to stop at next signal". The middle arm governs movements over limited speed route; the 90-degree position indicating "Proceed at limited speed"; and the 45-degree position indicating "Proceed at limited speed, prepared to stop at next signal". The bottom arm in the 45-degree position indicates "Proceed at low speed, prepared to stop".

Night indications of the signals are displayed by colored lights. Red is used to indicate "Stop" on all roads. On some roads, the caution indication is displayed by green light and the proceed indication by white light. On others yellow is used for displaying the caution indication, and green for the proceed indication.

It is advisable to distinguish between "Stop and stay" signals, used for manual blocking and interlocking, and the permissive signals, operated automatically. In the figures shown, the permissive signals have pointed end blades, the "Stop and stay" signals have square end blades, and this distinction is sufficient for daylight, when the blades can be seen.

In the upper-quadrant signals, as shown, the distinction is indicated at night by lights on the interlocking signals being placed in vertical line, permissive signals being distinguished by lights placed in a diagonal line.

These types of signals represent the most recent development, and are the result of work of the Railway Signal Association and the American Railway Engineering Association toward a uniform scheme of signaling. It has not been finally approved by the Committees, as there is a difference of opinion, but it is being used on a great many railroads in the east, handling heavy traffic, and will, without doubt, eventually be approved.

Practically no reference has been made to the engineering involved in the design, installation and maintenance of signals, except a few basic principles, but I will be pleased so far as possible to answer any questions you may have in regard to the subject.

Discussion

Mr. A. J. Himes:—

I would like to ask Mr. Denney to explain fully the difference in position of the semaphore signal for left-hand and right-hand operation.

Mr. C. E. Denney:—

For right-hand operation, signals are placed over or to the right of the track governed; for left-hand operation, over or to the left of the track governed. Engineers are on the right side of the engine cab and the objection to signals on the left of the track has been aggravated by the increase in the size of the engine boilers over which it is necessary for the engineer to look in reading the signal to the left of the track.

On steam lines, the blades point to the right of the pole. On some electric lines the blades point to the left in order to give a better background, the view of the blade to the right being considerably obstructed by the poles supporting the trolley wires.

Mr. Albert H. Bates:—

There is one branch of the signalling art which Mr. Denney has not touched upon that appeals greatly to the layman—however it may to the signal engineer—and that is the feature of automatically stopping moving trains. The idea has taken hold of the public that it would be an excellent thing to have the train stopped automatically if the engineer did not obey a signal, or did not understand it, or if the signal failed to work. In fact, there has been such a demand by the public for something of that kind, that Congress authorized a special board, a branch of the Interstate Commerce Commission, known as the Block Signal and Train Control Board, which was instituted largely to see what could be developed in the line of better control of trains, and particularly of automatic control. That board has reported that, out of a large number of devices submitted to it, some fifteen or twenty were considered by them as worthy of test by actual practice. Among those so recommended is an automatic stop, known as the Jones stop, devised in Atlanta, Ga. If I am advised correctly, Mr. Denney has seen this stop work in Atlanta, or vicinity, and I think it would be interesting to hear some remarks from him on that subject. I understand the New York Central has authorized a test of the Jones stop on the Niagara Falls branch, and that the owners are getting ready to make a test in snow and ice this winter.

Mr. C. E. Denney:—

The only automatic stops in service, of which I have any information, are in the New York subway, Boston subway and elevated, and one or two traction lines in the west. The stops in the subway and on the elevated work very satisfactorily, and they consist entirely of mechanical trips placed along the track. The apparatus which will work in a subway or on an elevated would not work on this Jan. 9, along Lake Erie, and it is hard to design something that will. I have seen the one referred to, and a great many others; some operate by electricity, some by induction, some by intermittent contact. Our friends, the inventors, have tried almost every way to accomplish the result, and I think it will yet be found. There is a field for it, although its general use is debatable. It is very easy to say that an automatic stop should have been installed at a certain place after an accident has hap-

pened, and if it had been installed *and working*, it might have saved that particular accident, but there are a good many requirements which place a hardship upon the designer of the apparatus. It must work when it is needed, it must not stop a train when it shouldn't, it probably will be needed only once in a very long time, and it must be practically infallible. If a device which is installed to stop a train should do so a few times when it was not necessary to stop, it would soon have a very bad reputation; while I think they are coming, I think it will be when we are very much older. They will be installed in locations of very dense traffic when the proper design is brought out.

Mr. E. P. Roberts:—

Concerning the remark a moment or two ago about the location of the arms, relative to the track, a great many of the systems put in now for interurban railroads are "light" systems, and when the traveler can see the lights he has an inward feeling of safety.

Mr. Denney:—

The light signals can be used economically on the electric line. I believe the longest range (in daylight) light signal which has been secured is about 1,500 feet.

Mr. Moffat:—

I want to mention "This World" signal which, I believe, is made to show against a white background. I would like to know if that is coming into general use, or if not, if there is a conviction it is not satisfactory.

Mr. Denney:—

I think the signal has been improperly named. It should be called "Next World" signal. (Laughter.) I don't think it will come into use.

Mr. Snider:—

There has been so much diversity of opinion among the interurbans about signals, and the lack of funds to install them, that I do not believe I am prepared to give you any information along this line. There is, however, a train dispatcher signal being worked out which seems to have some merit. It is operated by the dispatcher and calls the attention of the motorman to a signal in his cab, or car, at every switch. I know of seventeen miles which is being installed now out of Indianapolis, and it would seem to be the nearest thing to a practical interurban signal system.

Mr. Ray:—

I would like to hear something respecting the train order signal *induction* in connection with interlocking. You know on roads where the train has to proceed, where there is no block system at interlocking points, we have considerable variation in the manner in which the train order signals have to be given. Has that been considered? Or is there anything worked out?

Mr. Denney:—

Yes, the only road I know of, which gives a distinct *indication* of orders at interlocking is the Pittsburgh & Lake Erie. They place a left-hand upper quadrant arm on a line with the operating arm of the interlocking signal.

I think you will understand that one of the best things we can do in designing a signal system is to reduce the number of lights, or number of combinations. A man running at eighty miles an hour does not have much time to think whether he has all the lights or not. He should have to pick up only one set of lights.

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Safety as Applied to Engineering

By C. Eugene Pettibone.

Before entering into the subject of the evening, I desire to acknowledge a debt of gratitude to the American Steel & Wire Co., to whom I am obligated for most of the pictures that will be shown this evening.

It is impossible to determine definitely, or even approximately, the number of men injured yearly in the United States. In but few states is an adequate attempt made to compile statistics, and these vary so widely in their scope that their comparison for the purpose of obtaining useful data, is both useless and misleading. Using the ratios published in 1908 by the United States Bureau of Labor, there were approximately 40,000 fatal accidents last year. Conservative estimators have used 500,000 as the number of non-fatal accidents. From a purely commercial point of view, this means that we are yearly destroying 40,000 of our productive units, and forcing 40,000 more to be non-productive. To even approximate the yearly financial loss, we must add $8,000,000 paid in liability insurance, 60 per cent of the cost of our judicial system, which in New York State alone means $3,600,000 a year, together with over 20 per cent of the cost of our charitable institutions, hospitals and orphan asylums. Of this enormous waste, borne not only by the industries, but by the community in general, 50 per cent is preventable.

The greatest problems today before the engineering profession, in all of its many phases of work, are *higher efficiency* and *reduction of waste*. From these few facts, I believe you will agree with me that accident prevention is indeed a problem worthy of your consideration and the best engineering skill and ingenuity.

It is my purpose this evening to endeavor to present to you a few of the developments of what is popularly known as *safety work*, which, I think, will be of general interest to engineers. In treating the problem, I have divided it roughly into three divisions, viz.:—

(1)—Machinery (installation and design).
(2)—Power Equipment.
(3)—Construction.

Machinery

This is a very prolific source of accidents, most of which may be classified under the following dangerous mechanical elements, which are found on machinery and its appliances:—

(1)—All engaging gears, rolls and drums.

(2)—Shafting and spindles and all couplings or projections thereon, or upon reciprocating or revolving parts of machines.

(3)—Belts, bands and driving chains.

(4)—The spaces between fixed and moving parts of any machine, or between the latter and structures near it, leaving insufficient working clearance.

(5)—Flywheels and balance wheels.

(6)—Counterweights and other suspensions.

It has been estimated that projecting set screws yearly cause 1,500 accidents. In every case they should be eliminated or guarded. Shaft couplings should have perfectly smooth surfaces, and where face couplings are used the flanges ought to project sufficiently to cover the bolt heads and nuts.

It is, however, not necessary for a shaft to have projection to be dangerous. Men are constantly being wound around perfectly smooth shafts. A little pressure against the shaft produces enough friction to give the corner of a coat or jumper one lap around the shaft and the man is helplessly entangled and becomes a human pin wheel. It is, of course, impossible to cover all shafting and pulleys, but they should be guarded whenever men are required to work around them while they are in motion. The growing tendency toward individual motor drives will largely eliminate this hazard.

A few years ago, it was the prevailing attitude that only gears which were in close proximity to workmen were dangerous, and even then it was only considered necessary to protect the point of mesh on the side where they "run in".

One needs but to follow up the accidents in any large plant to become convinced that all gears are dangerous, regardless of their location. We have also learned, through sad experience, that no gear is properly guarded unless it is completely enclosed. This type of protection can best be taken care of in the original design, and machine tool makers are rapidly meeting these requirements.

To *keep* a machine guarded is frequently more difficult than to install guards. Guards are taken off while repairs or changes are made and the machine operated without their being replaced. All too often we enter a mill and find a machine running entirely unprotected, while the guard rests in some out-of-the-way corner. In New York State, there is a law which makes it an offense, punishable by imprisonment, to operate a machine without replacing guards after they have been removed. As engineers, we endeavor to accomplish the same result in the design of guards. A very common form of guard for the end gears of a lathe is a metal box open on one side, which sets on the floor. These, however, are frequently set off and the machine run unguarded. To overcome this difficulty, a rather unique guard has been designed. It consists of a sheet metal cabinet built onto the end of the lathe. The front, one side and top are hinged and can be thrown open to give access to the gearing. The sides, when open, block the passageway to such an extent that it precludes the possibility of their being left open when not in use. It also serves as a storage

place for the change gears. It furnishes complete protection, does not hamper operation, and is neat in appearance.

So far as possible, we endeavor to make guards automatic. If it is necessary for the operator to adjust a guard, he is very

FIG. 1—AUTOMATIC JOINTER GUARD

liable to allow it to remain in an inoperative position, especially if he has but little work to perform on the machine. Jointers, circular saws and most woodworking machinery can be equipped with automatic guards.

Fig. 1 shows a jointer guard that covers all exposed surfaces

of the revolving knives and requires no adjusting, being completely automatic.

Jointers may also be equipped with a safety cylinder, which fills in all but the portion of the revolving cutter necessary to make

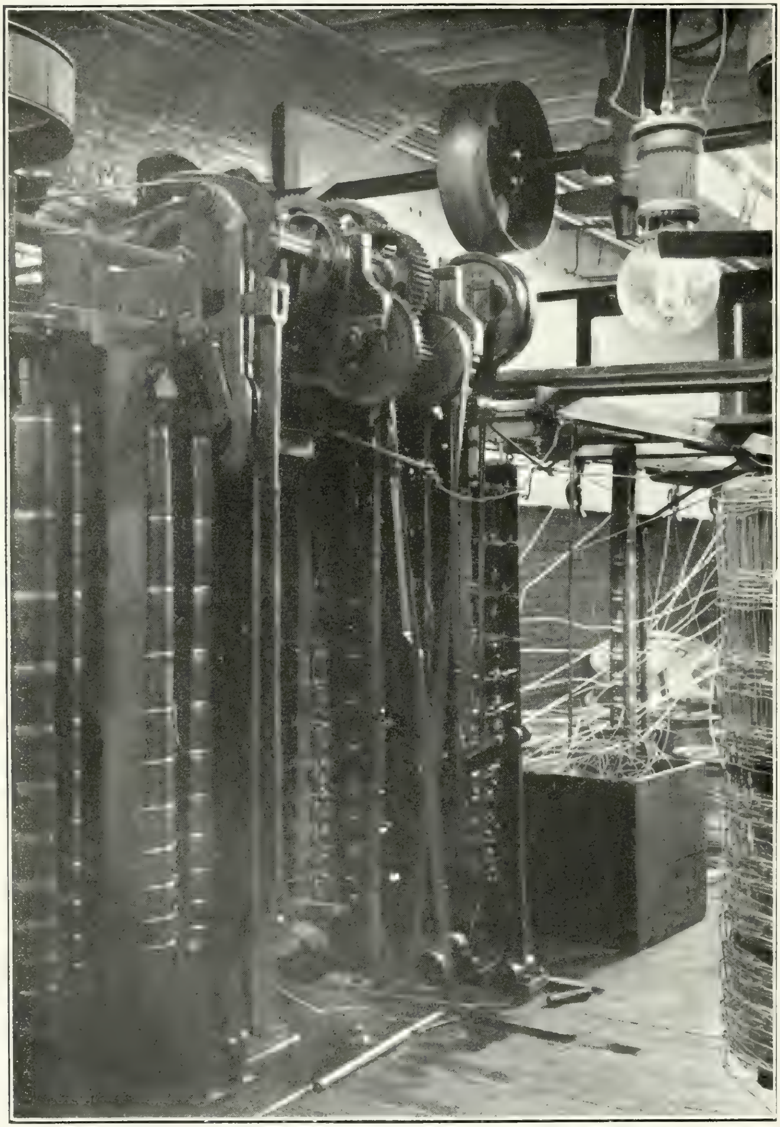

FIG. 2—AMERICAN FENCE MACHINE, UNGUARDED

the cut. This limits the extent of injury, which would be received in event the operator's hand comes into contact with the cutter. Without the safety cylinder the first cut would probably cut off half of the finger, while with it only a thin slice would be removed from the tip.

The most difficult problems in machine protection are those encountered in guarding special machines. Not to decrease production nor hamper operation in guarding machinery are very important features which merit careful study.

No guard or safety device which ultimately limits production can be considered entirely satisfactory. Even with this in mind, and giving full consideration to the many complicated conditions and operations which will be encountered, I believe that there does not exist a piece of machinery which cannot be well protected if we devote to it our careful consideration, ingenuity and engineering skill. Safety and efficiency should co-operate—not oppose.

Judgment as to the limitation of production should not be too hasty. Any change in method of operation or construction usually meets with temporary opposition from the operator, and always requires a period of time for adjustment to new conditions. This was exemplified in a block stop, installed in the wire drawing department of the American Steel & Wire Co. When first installed, the opposition was so strong that it was necessary to discharge a number of men who persisted in not using the stops, even though their use required practically no additional work. Today, the wire drawers would resent their removal. They have increased the production, and consequently the men's earning capacity and eliminated a class of very numerous accidents.

We will consider one case of guarding special machinery. Fig. 2 shows a machine for making wire fence, used by the American Steel & Wire Co. There are a large number of exposed gears at the top of the machine. The gears are located about 7 to 8 feet from the floor, and on no occasion is it necessary to work on or about them while the machine is in motion. Mill superintendents and safety committees considered these gears "not dangerous"; nevertheless, within a few weeks two men at different plants had their hands crushed in them. The problem of protecting this machine is typical of the problems which are encountered in designing guards for special machines. To make adjustment for different sizes of fence requires the changing of some of the top gears. The guard to be designed must, therefore, allow ready access to the gears. The gear changes are made from a portable step-ladder.

Fig. 3 shows how these conditions were met. The top gear guards are made in removable sections, thus furnishing easy access to the gears. A substantial platform has been erected, which provides a convenient place to work upon, and eliminates the danger of falling, which existed in the use of a ladder. The heavy wire mesh, of which the floor of the platform and gear covers are made, obstructs neither the operator's view of the working parts of the machine, nor the light upon his work. In front, and also at the side directly over the man's head are gears enclosed in sheet metal guards. Almost in front of the man is a bar grating, enclosing vibrating rolls. The grating prevents a hand, foot or head from being crushed between the rolls. The toe boards in front guard the projections on the roll. To the right and rear of the operator is a sheet metal door which covers a row of projecting adjusting set screws, which, although in the

center of the machine, it was advisable to guard. At the rear of the machine are the reels, from which the wire is fed. A cable runs the entire length on both sides of the reels, and is attached to the belt shifter. In case of emergency, the reel man can stop the machine by a pull on the cable, but he is unable to start it.

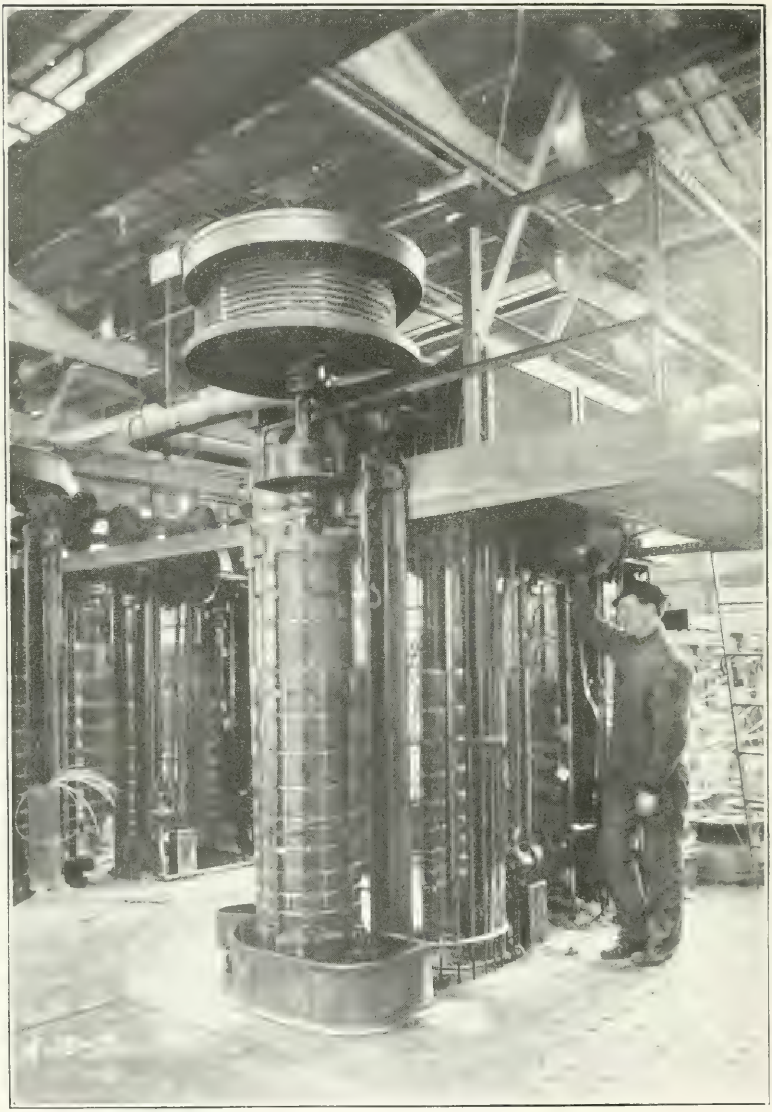

FIG. 3—AMERICAN FENCE MACHINE, GUARDED

The starting of a machine, due to the creeping of the belt from the loose to the tight pulley is a frequent cause of accidents. This machine is equipped with a shifter that makes it impossible for the belt to creep. The prongs that guide the belt are given

their lateral motion by a crank, which is on "dead center" when the belt is on either the tight or loose pulley. The crank is revolved by the operator to shift the belt. Variations of this shifter may be applied to most machines. This I consider a perfectly guarded machine, and in guarding operation has been aided, not impaired.

Power Equipment

The dangers incidental to the operation of boilers have been so generally recognized that their construction and operation has been proscribed by law, which, together with numerous publications by boiler insurance companies, and others, make their extensive consideration here unnecessary. Undoubtedly, the best protection is the periodic inspection by competent inspectors. To prevent explosion, I should consider the use of non-return valves second only to safety valves. The non-return valve is placed in the header of each boiler, and is so constructed that it will automatically close when there is a difference in pressure of from three to five pounds around the valve. In event of the breaking of tube in one boiler, the valve prevents the rushing of the steam from the rest of the battery into the boiler, and also precludes the possibility of putting a boiler on the line before it is up to pressure.

BOILERS

Next to explosions, the most serious accidents are caused by the turning of feed water or steam into a boiler while men are within, making repairs. Such accidents can best be prevented by the locking of the valves, allowing the man within the boiler to keep the key. Accidents have occurred where a defective valve has allowed the steam to enter the boiler and scald the men working inside. Some companies require two halves on these connections to overcome this possibility.

It is essential that all valves above boiler should be readily accessible. Injuries from steam or flying glass frequently occur with the breaking of a gauge glass. A simple, but effective gauge glass guard may be made of a semi-cylindrical piece of sheet metal, arranged so that it may be turned either to front or rear of the glass. Normally the guard remains at the rear of the glass. When a new glass is warmed up, the guard is turned to the front to protect the operator. The valves above and below the glass should be quick-acting valves, which can be opened or closed by a single pull of the chain, making it unnecessary to climb into escaping steam to shut off the column when the glass breaks.

Statistics show that accidents from the bursting of flywheels yearly exceed by 30 per cent the accidents from boiler explosions. The safeguarding of large engines is, therefore, an important consideration. The Corliss type of valve gear and governor is often so constructed that when the engine slows down a certain number of revolutions below normal speed, the governor comes down to a point where the safety cams prevent the valves from hooking up, thus cutting off the steam and stalling the engine. This method of construction is followed, in order to protect the engine in case of an accident to any of the driving parts of the governor. It is evident that when

ENGINES

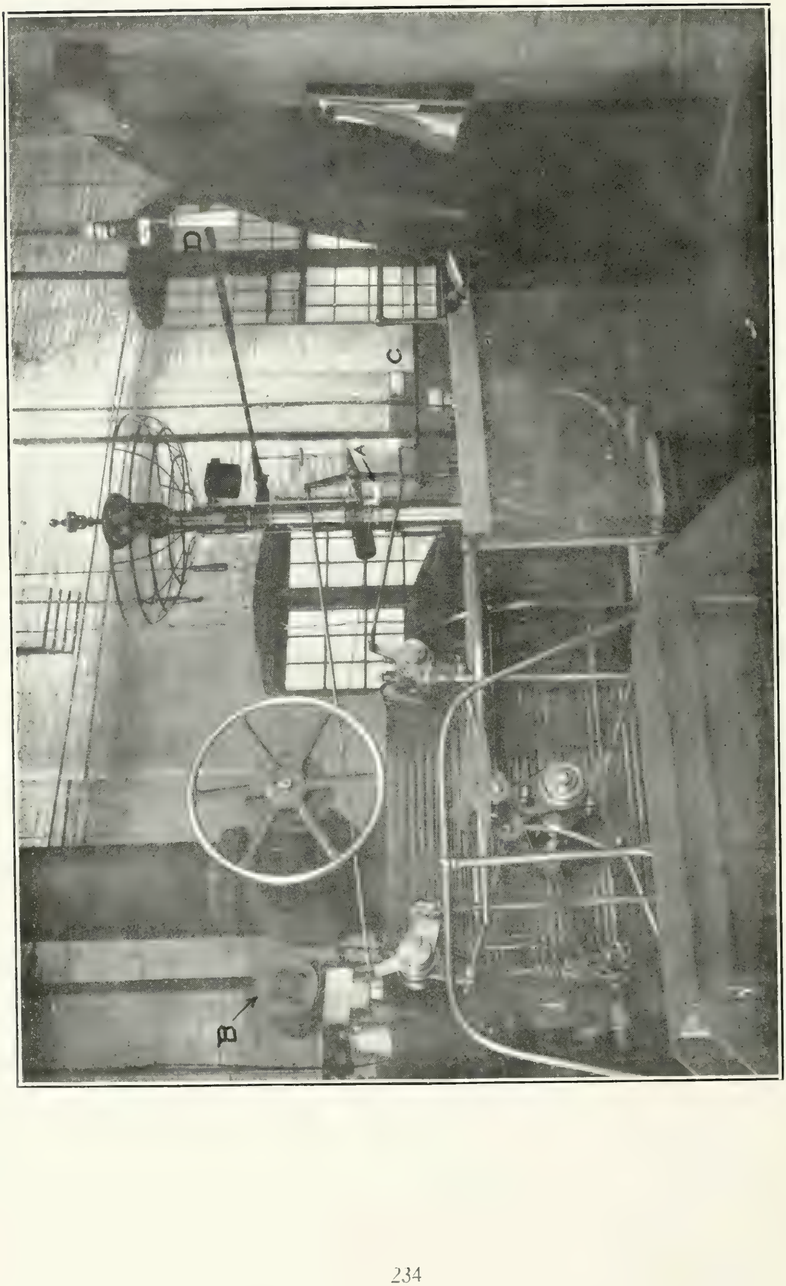

FIG. 4—LARGE ENGINE PROTECTION

stopping the engine, it is necessary to prevent the governor from falling below the position of longest cut-off, that is, the point at which the safety cams become operative, in order that the engine may again be started without adjusting the valve motion. To accomplish this, a collar is turned under the governor. Upon starting the engine, this collar should be turned out. If, in the abstraction of his many duties, the engineer neglects to turn out the collar, an accident to the governor driving mechanism will allow the governor to fall to the point of longest cut-off, causing the engine to speed up and possibly be wrecked. Even engineers' memories are not infallible, so we have arranged a counter-weighted bracket to take the place of the collar. The bracket can be held in place by a cord running to the throttle, but will immediately fall out of position when relieved of the weight of the governor. (*A*, Fig. 4.)

There are conditions when the failure to turn the collar to the safe position is not due to the forgetfulness of the engineer. In a great many cases Corliss engines are working, intermittently, under conditions of heavy load, where the load will cause the engine to slow down to the point where the safety cams will cut off the steam. Under these conditions the only means to prevent the engine from stalling is to operate it with the ordinary safety stop in position under the governor.

To meet this condition a device has been arranged to counter-balance the governor at the point of longest cut-off, so that the governor will practically have to cease to revolve before the counterbalance will be tripped and the steam shut off. A weight on a counterbalance lever can be so adjusted that the steam will cut off at any desired speed. The sensitiveness of the governor is not impaired, for the device only touches it at the point of longest cut-off. The function of the device is simply to support the governor at this point until the engine slows down a pre-determined number of revolutions, when the weight of the governor will trip the counterbalance and shut off the steam. In case of an accident to the governor driving apparatus the governor will slow down and its weight will trip the counterbalance.

B, Fig. 4, is an automatic engine stop; an arrangement, by means of which the throttle may be closed from push-buttons located at intervals throughout the mill and in various places in the engine room (*C*, Fig. 4). The falling of a weight, electro-magnetically released, furnishes the power to operate the throttle. The current for the push-button circuit is supplied from one of two sets of storage batteries, which are alternately charged and put on the circuit. A daily test is made of each button to insure its reliable operation. Each button is marked by a blue light and sign reading "Engine Stop. In Case of Emergency Push Button".

A speed limit stop, driven from the governor shaft, operates the automatic stop when the flywheel reaches a prohibitive speed. An additional means of shutting down the engine, independent of the engine mechanism, is furnished by a butterfly valve in the steam line, operated by several suspended cords in the engine room. (*D*, Fig. 4.) Guards around the governor balls to protect the oilers from being struck by the revolving balls, and guards in

front of the governor drive and belt drive, are also shown in Fig. 4.

A condition parallel to the over-speeding of an engine and the resultant bursting of the flywheel mentioned above is possible in certain types of motors. If through some accident the shunt field circuit of a shunt or compound wound motor is opened and the motor is not instantly disconnected from the line, the motor will attain a dangerous peripheral speed, which will burst the armature. Particularly is this true of a compound wound motor driving a light load. Recently the Electric Controller & Mfg. Co. put on the market a balanced protective relay, to eliminate this danger. The windings of the relay are connected in series with the shunt field and the contact in series with the windings of a magnetic switch in the motor circuit. The so-called "gravity dash-pot" balances momentary fluctuations in the shunt field circuit, but immediately opens the main line magnetic switch upon failure of the field circuit.

MOTORS

The problem of stopping the prime mover from a distance is more easily accomplished when the prime mover is a motor than when it is an engine. There are on the market today automatic starters which make it possible to both start and stop motors by the use of push-buttons. Where automatic starters are not in use, push-button motor stops may be installed in any of the following ways:—

(1)—Pull out the main line switch by means of a cable.

(2)—A solenoid or magnetic switch in the main circuit which is kept "in" by a series of closed circuit push-buttons, and so arranged that the closing of the solenoid switch must be done by hand, thus preventing the motor from being started from the stopping point.

(3)—A circuit breaker in the main line, equipped with a "no voltage release" coil, the circuit of which is completed through a series of closed circuit push-buttons, or switches.

(4)—A system of closed circuit push-buttons, or switches, in series with the magnet which retains the starting lever when the motor is running, and in this case, breaking of the circuit by means of one of the buttons releases the starting lever and stops the motor. When using this arrangement care must be taken to see that the spring operating the starting lever is strong enough to throw it to the "off" position—otherwise the stop will be ineffective.

Electrical engineers have probably given more consideration to safety than any other class of engineers. Several of the recent meetings of the Association of Iron and Steel Electrical Engineers have been devoted almost entirely to *safety,* with very gratifying results.

The Carnegie Steel Co. has recently published a hand book entitled "Rules and Regulations for the Installation of Electric Wiring and Apparatus", to which the various companies comprising the United States Steel Corporation contributed. Their engineers, entering upon the subject endowed with his wide practical and theoretical knowledge, have given the subject such care-

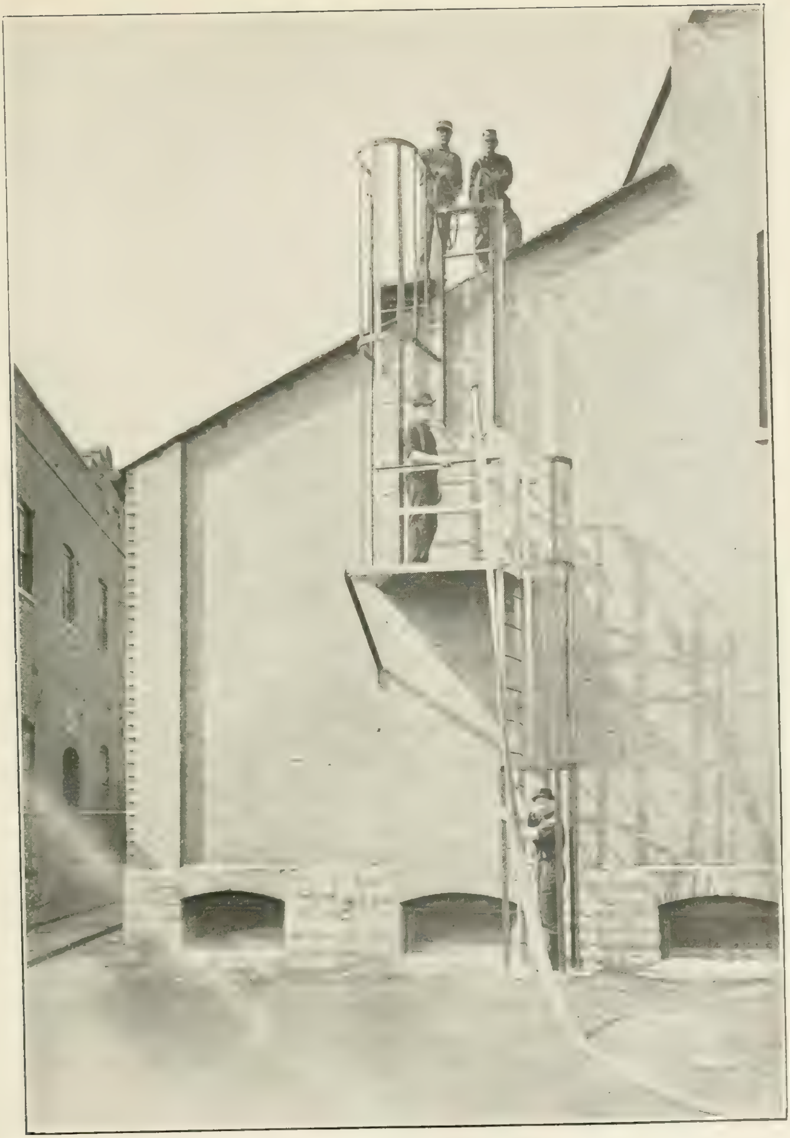

FIG. 6—SAFETY CAGE FOR LADDER

ful study that we are hardly justified in treating it here tonight.

The Association of Iron and Steel Electrical Engineers placed the division between high and low voltage, when applied to mill work, at 275 volts, which means that all equipment carrying voltages of 275 or over will receive special protection.

Among the first apparatus to receive attention were high voltage switchboards. All apparatus requiring periodic inspection is removed from behind the board, and the space enclosed by wire mesh fence and a locked gate. Under these conditions it is only

necessary for the electrician to enter the enclosure in case of "trouble", in which case he must go accompanied. All transformer rooms, lightning arresters, etc., are guarded and locked against persons whose duty does not require them to enter.

Construction

No accident list is complete without a generous contribution from ladders, although to the casual observer they may appear like the most simple and harmless piece of equipment imaginable.

LADDERS

German statistics attribute 20 per cent of all industrial accidents to falls from ladders, nor is this surprising when we consider that the breaking of a worn or defective part, the slipping of a hand or foot from a rung, or a little dizziness may in many cases mean a fall of 50 or even 100 feet.

It is possible in many cases to replace a ladder with a stairway, which workmen can ascend and descend without risk, even when carrying tools or repair parts. Frequently lack of sufficient space and mechanical considerations preclude the substitution of a stairway and the vertical ladder seems to furnish the only possible solution.

To meet this condition, a safety cage has been designed. (Fig. 6.) The cage consists of five parallel bars ($\frac{3}{8}$x$1\frac{1}{2}$ inches), held in position by circular bands ($\frac{3}{8}$x2 inches), making in effect a tube, with an internal diameter of 27 inches, inside of which the workman climbs. It would almost be possible for an armless man to go up and down such a ladder, using only his feet on the rungs. The cage is particularly advantageous at blast furnaces, where the presence of gas affords an added increment of danger. The ore unloaders on the Buffalo dock of Pickands, Mather & Co., are equipped with caged ladders; there severe weather conditions make the cage greatly appreciated by the men.

When you have designed your building and determined the location of the cranes and windows, stop and consider how the crane operator is going to reach his cab, and on what the men are going to stand when they clean the windows. Do not expect them to climb a latticed column and walk the crane runway track—give them a stairway and a walk.

In modern practice a walk is installed, running the entire length of the crane runway, from which one can step onto the walk along the crane bridge girder, making it possible to get to the crane in any position on the runway. (A typical design is shown in the United States Steel Corporation Committee of Safety Bulletin No. 2.)

CRANES

In a study of industrial accidents in the Pittsburgh district during the year of July, 1906, to July, 1907, Miss Eastman, writing for the *Pittsburgh Survey*, found that of the 195 fatalities in the steel industry, 42 or 21.5 per cent were caused by cranes. In the case of one company, cranes were responsible for 50 per cent of their fatalities. Probably no single type of equipment has experienced so many changes in design to comply with safety requirements as have cranes in the

last five years. Let us consider what we have done to eliminate the crane accidents, as described by Miss Eastman. Of the 42 fatalities, 21.4 per cent were due to being "run over or knocked off by unexpected movement of crane". We have furnished the men a walk to reach the crane, as just described, thus eliminating the necessity of their walking the track. In addition a walk is installed the entire length of the crane girder on one or both sides, and where construction makes it advisable, a walk is placed on the trolley for use in oiling, repairing and examining cables. A plate guard is installed in front of the traction wheels, which will brush a hand or foot off the rail.

Of the fatalities, 9.5 per cent were due to "parts of crane gearing that fell". All gears are completely enclosed in cases strong enough to retain the gear if it should work loose. All brake shoes and other parts, which might work loose and fall, are provided with means for retaining them. Some companies even attach every nut with a chain.

Of the fatalities, 9.5 per cent were due to "breaking of chains". The condition of a chain is always an uncertain quantity. A link may be badly crystallized, yet on the surface show no indication of its weakened condition. Chains have largely been replaced by wire cable. With at least weekly inspection of the cables this class of accidents may be entirely eliminated.

Frequently accidents occur by the falling of a load, due to the failure of the brakes to hold. When it is considered that the energy of a lowering load absorbed by a brake in the form of heat, is equivalent to approximately 60 per cent of the work done by the motor in hoisting the load, one can readily see the reason why brakes soon become inefficient where heavy loads are constantly being moved. To overcome this, what is known as "dynamic braking" may be installed. With dynamic braking brakes are not used in the lowering of a load, the work being done entirely by the motor. A solenoid brake is used to hold the load, but is not in operation during the lowering. When the controller is brought to the lowering position, both the armature and field windings of the motor remain connected to the line regardless of the load. Under conditions of light hook, both field and armature take current from the line. When the load is heavy enough to overhaul the hoisting mechanism, the field will continue to take power from the line, and the armature will promptly begin to return power to the line. The current generated by the armature is not dissipated in resistance, but is actually delivered to the line. Excessive heating does not take place in the armature, as experimental tests have shown that with a load requiring a mean hoisting current of 125 amperes, a mean lowering current of 85 amperes is returned to the line by the armature, the time of lowering being 40 per cent of the time of hoisting. Under these conditions the heating of the armature in lowering is approximately 15.5 per cent of that during hoisting.

When men are working on or about machinery, it is essential that they be absolutely protected against the possibility of someone thoughtlessly turning on the power. To accomplish this, a sign reading "Do Not Turn This Valve" or "Do Not Throw This

Switch" is kept in a convenient place for the repairmen to attach to the starting valve or switch. More positive than this is the use of a lock. This type of protection is particularly advantageous on cranes. To make protection more complete, we are inserting the following paragraph in our crane specifications:

> "Switchboard and its equipment to be enclosed in asbestos-lined, steel cabinet, with swinging door arranged so it can be locked. In addition to the one on the crane switchboard, there shall be a main line switch, mounted above the cage, where it can be conveniently reached from foot walk; this switch must be so constructed that it can be locked in the open position. An individual switch shall be located on each motor, for use of inspectors, etc., and be so arranged that it will throw out by gravity. All switches mentioned in this paragraph shall be of an approved enclosed type."

Discussion

Mr. Beyer:—

Members of the Cleveland Engineering Society:—It seems to me particularly appropriate that engineering societies, and engineers individually, should give consideration to safety problems, and work for safety improvements for two principal reasons. One is the very urgent need of standardization, and the other is the peculiarly advantageous position that engineers occupy, for applying safety measures with the minimum of expense and trouble.

As regards the need of standardization—at present, safety work is in a formative state. It is just being developed, it has not been perfected yet, and we know that the device that we consider satisfactory today will be improved upon tomorrow. The condition, as regards the manufacturer, is being rendered more acute all the time by the great flood of legislation that is coming up all over the country. There are about ten or twelve states that have adopted stringent employers' liability acts—Ohio, New York, Michigan, Wisconsin, Illinois, New Jersey, Massachusetts, and in almost all of those laws the employer is held liable for practically all accidents. In one of the states the indemnity is doubled if all statutory provisions have not been complied with, and those statutory provisions are, in nearly all cases, vague and indefinite.

For instance, the New York law says, "If a machine or any part thereof is in a dangerous condition, or is not properly guarded, the use thereof may be prohibited by the commissioner of labor," etc. This practically holds one man responsible for deciding whether or not the machinery is properly guarded, and as even an engineer may change his mind, it is not impossible that a factory inspector might do the same thing; so "properly guarded" is rather indefinite, to say the least.

The Pennsylvania laws say, "*Whenever possible,* belt shifters shall be installed," that "all saws, knives, cogs, shafting, gearing, planers, set screws," etc., shall be properly guarded; but they don't say what "properly guarded" means, and it is put in such a vague way that there is the chance for endless argument as to when a machine *is* "properly guarded". The standard is exceedingly variable, and we have no set standards even in respect to gearing. A constant flood of new machinery is being turned out and there is hardly any class of machinery today that has properly protected gears. It is often found after it is received in a manufacturing plant, that it is impossible to guard the gearing, when this might have been done in the first place, without difficulty, and at practically no expense.

I know of one order placed recently, and notwithstanding the fact that safety specifications were made a part of the contract, saying that all gearing should be entirely enclosed (and the words "entirely enclosed" were put in italics for the sake of emphasis), when those machines were received in the mills, about thirty out of a total of eighty had open gearing; on taking the matter up with the various manufacturers, they complied with the requirement by furnishing covers, or by footing the bill and having the covers installed. Now, several of those manufacturers, when the matter was taken up with them, would insist that this particular pair of gears were not dangerous, that a man would have to go up and actually stick his hand in the gears before he could be caught in them—but you and I know that just that sort of thing does happen. I know of cases where men have been caught and they could not explain afterward how it occurred. They said they did not know how they got their hands in the gears.

There are occasions where a man slips, puts out his hand to regain his balance, and is caught. One place I know where a pair of gears was located between two machines; the gears were covered over the top so that you would think they were entirely safe. A girl dropped her glasses, stooped down and reached in to pick them up and, in raising her head, the teeth of the gears caught her hair and her scalp was badly lacerated.

There are so many individual cases of this kind which might be cited, that the logical conclusion is—that all gearing should be entirely enclosed.

Now, if that were adopted as a standard, that one simple provision, for all new machinery that was turned out, and the manufacturers were made to comply with that single specification—it would greatly reduce the work and the trouble of the man who is trying to get protected machinery in the mills, and would do away with a lot of accidents.

As regards the position of the engineer in supplying safeguards—in very many cases it is possible when machinery or installations of any sort are being put in, to get them for practically nothing, if due provision is made by the designer; whereas, after the machinery has been installed, it is almost impossible to get them at any expense. I know of one mill, where conditions are notably unsafe, and yet to correct those conditions would mean practically the rebuilding of the entire mill. That condition

could have been taken care of at relatively slight expense at the time the mill was being designed, but now it would mean scrapping of numerous parts and a great deal of expense, because inadequate consideration was given to safety at the time the mill was built. So we see that, as regards the standardization of safeguards, and getting safe conditions at the least expense of time and energy, an engineer has the most fortuitous position for bringing about these conditions.

Some methods have been adopted by the American Steel & Wire Co., as well as the other subsidiary companies of the United States Steel Corporation, for bringing about standardization and for installing proper safe-guards at the time the machinery is built.

This sign is about 3 feet square (indicating lantern picture on screen), "Attention, draftsmen—Take the necessary time and see that every drawing you make fully provides for the safety of the employe."

This (indicating lantern picture thrown on screen) shows standard title plate for drawings and the rules for its use, and you will notice under Fig. 5 every drawing must be "checked for safety" and the initial of the person who makes this check must be shown.

(Another picture thrown on screen.) Then certain devices are standardized. We have a large number of drawings of this sort, this one showing an arrangement of hoods and protective devices for emery wheels. Those three different types of hoods are applicable to almost any kind of grinding wheel. Here is a plate glass guard (indicating on picture) that is installed to protect the man's eyes from flying pieces; and here are various rules regarding the mounting and upkeep of grinders—for instance, flanges one-half the diameter of the wheel, with cushion washers underneath (of course, every emery wheel is brittle like glass and if the flanges are tightened up unequally, it may break before any work is done at all). A safety cushion washer of blotting paper or fiber underneath the flanges, relieves and equalizes the pressure. I have never known a wheel mounted in this manner to "explode", although the flanges only need to be about one-half the diameter of the wheel.

Several other pictures were thrown on the screen and described by Mr. Beyer.

This shows some of the methods that are being used for securing safe construction, and for developing standards that can be worked to intelligently, and this is surely an object worthy of the interest and co-operation of engineers.

Mr. Roberts:—

In addition to the financial loss, as stated, I presume that each one of us has seen very sad cases and knows something of the results on the family, the wives and children, and how many have gone to the bad as the result of the father's inability to longer sustain the family. Not many of us think of engineering from an altruistic standpoint, but it has been pointed out that we can

n t only take part in safeguarding machinery, but also that we can be of value in the world outside of our profession.

Mr. Carman:—

I do not know that I have anything to say, but inasmuch as you call on me, I will say that since listening to these splendid talks, I feel as one who has been a little bit careless in the designing of machinery.

It seems to me that we, as engineers, have had trouble enough in designing the machine mechanically to produce the desired results without having to look after the safety of it, but nevertheless I realize that there is another duty to perform besides that of producing a machine having in mind the saving of dollars and cents only.

I realize now that we owe the man who is to use the machine a certain duty, and we, as engineers, should give the safety of the machine more consideration than we do.

Referring to the clause regarding the safety of the machine being inserted in the specifications, which the speaker referred to, I would say that very often this clause is inserted in such a way that it is left optional with the bidder as to whether the machine is safely guarded, and again it is inserted and the purchaser expects a machine fully guarded at the same price as a machine that is not guarded, therefore we find it hard to provide ample safety guards and compete with the man who is bidding on the same machine and has entirely ignored the clause.

However, I believe that the buyer and the engineer should both insist on a guarded machine—the buyer being willing to pay for same, as their cost in nine cases out of ten is a large part of the cost of the whole machine.

Mr. Melendy:—

One subject I might speak of is the goggles for the protection of eyes of workmen who are working where there is danger of injury to the eyes. In many cases it has been required that they be worn, but it has been extremely hard to keep them on the men. They take them off as soon as one's back is turned, and we have found, in questioning the men, that they irritate their eyes. We have posted signs that they must wash their eyes before and after wearing the goggles, if they are rubber rimmed; and we use wire gauze rims for places where the danger is from flying particles only. That has minimized our accidents very largely.

Mr. Gaehr:—

I doubt, Mr. Chairman, that I can contribute any discussion of value. Concerning the application of safety devices to conveying machinery, I cannot say that any characteristic or novel features have been brought out. I do not believe that any special study has been made of that particular sphere of application. Of course, the principal parts of machinery, such as gears, etc., are being treated, in many cases, in the manner referred to by the speaker of the evening.

If I may express some of my personal views on the subject as a whole, I would say that in a general way, naturally, I heartily endorse the movement to reduce the chance of accident by intelligent and persistent observance of precautionary measures.

I have not been quite in sympathy, however, with some demands for "safety appliances" made by some employers' liability insurance companies, because I feel that many of them unduly restrict the freedom of the operator, and some of them are positively ridiculous and even direct sources of danger.

As to the restriction of freedom, the mechanical belt shifter used in connection with cone pulleys might be mentioned. Personally I, being myself a machinist by trade, shall always prefer to throw the belt in the old way and believe that by observing such precautions as avoiding the wearing of finger rings (which have at times been caught on metallic belt laces, etc.) an operator can throw a belt safely and quicker by hand than by cumbersome mechanical devices.

The principle involved is akin to that governing the doors on enclosed rear platforms of street cars. It seems to me that, if a pedestrian wants to jump on or off a moving street car, at his own risk, he ought to be granted that privilege (laughter), and physically active and alert men should not be made subject to restrictions which may be a safeguard for children, women and those physically infirm and awkward, but may also make a regular death trap of a car in emergencies.

So, I rather think that, if employers are willing to provide safety devices which the ingenuity of experienced men may advise (not products of theoretical and inexperienced enthusiasts), that is about as far as they should go or be expected to go. The wisdom of enforcing such measures, against the opposition of those for whose benefit they are intended, seems most questionable.

There are, of course, exceptions and frequently men of low intellectual standard or prejudiced actually do not recognize things as concerning their interests.

There should be "moderation in all things", even in the application of safety measures, and for some obviously this designation is a misnomer. We should also remember that Americans are prone to be extremists, swinging like the pendulum from one limit to that opposite.

We should treat cases in the order of their importance.

By enforcing all possible means considered as effective in preventing accidents, it seems to me there is created a more or less erroneous atmosphere of immunity from accident. "Safety" seems to be in the very air, and this most assuredly tends to make men working in such environments less careful about protecting themselves, in fact, I believe that a spirit of carelessness is actually engendered thereby which makes itself felt even in the standard of work. The elements enunciated are quite similar to those which made the Pilgrim fathers, who were ever ready to protect themselves against unexpected attacks from Indians, far more capable of taking care of themselves in almost any kind of an

emergency than are our present day city folks, accustomed to hold others largely responsible for their safety.

So safety measures may at times actually increase danger, and, by way of illustration, I would refer to some of the photographs of boring mills and lathes shown on the screen.

Change gears and driving gears were shown caged in and locked up like wild animals in some cases, and in most cases these were located in places where the operator "had no business", while the machine is running. Granting their propriety, nevertheless, they surely tend to relieve the operator of some of the responsiblity of being on "his metal" and would leave him the less prepared to be on his guard at the most dangerous places around the machines, namely right at the revolving work, where he has "business" and where no guards can be provided because of the ever changing character of the work. Everyone thoroughly acquainted with the operation of such tools knows that there is danger from "getting caught" between the stationary parts of the machines, especially the tool and its support, and the moving masses of metal or other material, and frequently operators have to take measurements on such. On large boring mills, at times operators even walk around on the revolving tables while in motion. There always were and always will be machines which demand nerve and physical dexterity on the part of operators and, once they are accustomed to their duties, they perform them far more safely than timid or careless men for whose safety others have provided all manner of special devices. Anything done, therefore, to diminish these characteristics of care and skill will increase the hazard for such individuals.

Another point might well be emphasized. The totally enclosing of machine parts for reasons of safety or cleanliness, has often led to disaster, because the attendants could not observe signs of imminent danger, such as loose nuts, loosened keys, hot bearings, which would have been of little consequence if promptly looked after, but, when hidden from view, received no attention until the machine was completely wrecked.

So, let us fairly size up this question of safety appliances from all view points and not fool ourselves in considering all things safe which have guards around them.

Mr. Herron:—

I am not as directly interested in this subject as others, having practically no employes to safeguard, but it has seemed to me, after some consideration, that the engineer is largely responsible for providing proper safeguards in the preparation of his specifications. Such specifications should cover the matter fully.

Mr. Carman has spoken of the manufacturer being expected to supply the safeguards for machines that he manufactures. If in the specifications such safeguards are provided, all manufacturers bidding on such specifications have an equal chance and there is no hardship felt by any one of the manufacturers.

There have been many accidents in the past in the use of machine tools, but there is now more or less of a systematic effort being made by machine tool manufacturers to provide safeguards,

so that the operators of such machines may be protected. As was indicated in some of the pictures this evening, the Bullard mill is perhaps a good example of this development and in this case no gears are exposed. This can also be said of the Lodge & Shipley lathe, which was shown. Machine tools, of a few years since, had all the gears exposed, consequently resulting in accidents to a considerable extent. There have been a great many minor accidents in machine shops, but the day is rapidly passing, and now these are comparatively rare.

I wish to go back to the original point and emphasize that it is the responsibility of the engineer to draw such specifications that all dangerous parts of any machine will be covered and the lives of the operatives be protected.

Mr. Luckiesh :—

Mr. Chairman :—One safeguard that has not been mentioned tonight—good light—it seems to me is a safeguard that could be easily applied. I would like to ask Mr. Pettibone the per cent of accidents that is due to defective lighting. I was surprised to find that during the winter months the percentage of industrial accidents rose 50 per cent, I attributed this increase somewhat to defective light. There is very little legislation in regard to industrial lighting, and the little that there is, is very vague and defective. I believe that poor lighting is very often the cause of accidents.

Mr. Bach :—

In the matter of accidents in machines, a good many accidents occur in hurry-up jobs—in break-down jobs—all of us men who have operated machines or engines have seen someone injured in a hurry-up job; I myself have escaped very narrowly, and I find a great many accidents occur in emergencies. While we are doing that work in a hurry we are overlooking a lot of safeguards, which should be taken care of when machinery is built, and thus take the burden of looking out for one's safety off the mind of the operator, which should be entirely free for his work; the men in charge of such work should be on the lookout for accidents at this time.

Mr. K. H. Osborn :—

Mention has been made of the use of stairways in preference to ladders. I have visited most of the buildings which have been erected in this city lately, and although I have not heard of any accidents due to ladders, still it has impressed me that contractors' ladders were poor propositions. The building code requires that in all buildings over three stories high temporary stairs should be installed. However, that provision of the building code, like many others, has been frequently violated. It seems to me that if engineers would see that contractors obey this regulation, they could thereby add to the safety and also to the convenience of the workmen.

Mr. C. D. Palmer :—

Mr. Chairman, it has been my experience in reference to factory work that there are some things that come up at a date

too far along for the engineers, and it seems to me that as long as we have an inspector provided by law that that inspector should be sufficiently familiar with factory work to know what he is talking about. It seems to me that there are a good many of them who are appointed through political influence or something of that sort, and that there is very little real, practical knowledge that enables that man to *know what* he is talking about; in a factory that my father had at one time, the inspector came and ordered certain changes made; father thought that they were entirely useless. He could not see what the benefit was to be. But over in another place was an old boring machine, on which there were little set screws that stuck out about an inch. One morning father had occasion to use the machine and reaching up, put the belt on; of course, the mandrel started very suddenly, and having forgotten to remove his foot, the set screw tore off the end of his shoe and with it a part of his toe. Now, there *was a need,* it seems to me, that the inspector should have been looking for instead of the thing that would make a good show in the factory. I remember another time, I was sitting in front of a bit that was running; just for the moment I turned around, it struck my trousers leg and the bit ran off with the biggest part of the garment. It seems to me that what is wanted is common sense building laws and inspection by competent factory inspectors, upon whose judgment the manufacturer can rely for authentic "liability" protection and whose certificate would exonerate the manufacturers in the event of accident to employes for the reason that he is forcibly taught to depend upon the inspectors' opinion in such matters.

Mr. Marani:—

I come to the defense of the inspector for this reason, and that is that the public and engineers in general have a misconception of the duties of an inspector. The inspector is only empowered to give a general, and not a detailed, inspection. Just the same as the duties of the chief of the fire department, or the chief of the police department. If the fire chief is notified that a building is burning, and he gets to the wrong corner, he is not considered negligent of his duty or a fool; nor is the chief of police, if you go home at night and on the way are robbed, and the thief is never caught, and the chief still holds his job. I agree with the fact that there should be detailed inspection, but what are you going to do when you have one man looking after a hundred and thirty-four buildings? When a building is being erected, the inspector goes to that building and he sees the safety guards, etc., called for by law, are in place, he proceeds to the next building and immediately down come the safety guards on the building he has just inspected. These questions of safety have their humorous side. In trying to amend the building code and give the men erecting buildings more protection, we thought of making the erection of the skyscraper as safe for workmen as a three-story building. So we drew up an ordinance, which we thought was adequate protection, but what was the result? I had a very pleasant visit from a committee of the union men,

who said that if this ridiculous ordinance became a part of the building code, any fool could go on a building and erect steel, it would take away their high prices, and they wouldn't get those high prices if they didn't have the danger of working 180 feet up in the air. Now, the same thing applies exactly to the plumbers. They wanted to have vent pipes in a building far in excess of what was necessary; the more pipes there were, the better they liked it. In the case of a laundry here in town they wanted vent pipes put in that were wholly unnecessary, and when we wanted to revise the plumbing code to do away with this unnecessary work, a delegation from the plumbers' union called upon me and told me that my position was ridiculous, that it was necessary for the health of the public, and that in this particular case these pipes were necessary because the plumbing would be no good if all traps were not thoroughly ventilated. The result of this situation was that I showed them the plan I had was adequate and that all that was necessary was embodied in what we proposed. The man said, "But don't you know, you fool, that any fool under that plan could erect plumbing, and so where is our job coming in?" (Laughter.)

However, there is a good deal of common sense in the protection of machinery, though some think that an element of danger accompanying their position helps their wages. This talk tonight has been very excellent, and it has dawned upon me in the case of the gas company plants in this city, which I designed, that I did not give the safety feature enough thought, but I will promise to think of safety, together with design, in the future. So little money would have been necessary in the case of the gas company to protect life. In the coal sheds that store coal 30 feet high, the man goes to these sheds and gets the coal from the bottom of the pile into the wagon. While they were loosening lumps below a coal slide would often take place and the fellow was hurt and then the company usually paid the doctor's bill. Then there is the question of a gas holder blowing, where men have been known to be asphyxiated, but by some simple device the flow of gas could have been shut off if the proper precautions had been taken in the design of this feature of the plant. Then, too, there is nothing to prevent a man from falling into the generator cupola of a water gas plant, which is about 36 inches in diameter, and being cremated. If we object to that sort of thing when we are dead, we certainly object more strongly to it while we are alive. I might have protected that when I worked there, but I was too busy drawing my pay and certain other duties, mostly in the line of economical design.

Mr. Beyer:—

As regards that point of inspection, it might be an interesting psychological study if we could determine whether the man would have been as much impressed with the danger of set screws before he had caught his foot as he was after. (Laughter.) I have seen just such cases, where a man would argue that there was no danger, until someone was injured; then instantly he sees the danger which was there all the time.

As regards the point one of the gentlemen made about the

application of safeguards, and the attitude of the government in demanding safeguards. It is an interesting point in that connection to note that the trend of opinion has been quite reversed on this particular matter in the past few years. It used to be that the "assumption of risk" was one of the standard defenses. That is, that the workman undertaking any particular job assumed the risk; that he knew there were certain dangers, and that his pay covered those dangers. That was a part of the thing that he was paid for and a risk which he agreed to stand in accepting the job. Practically all the employers' liability laws, which are now being enacted, have swept away this defense. They say the man's wages is *not* sufficient to cover the risk. They look at it more from the sociological standpoint. For example:—If a shaft or a gear is broken, that is charged to the production cost. It means a certain added per cent on the output, for which the consumer (for whom the work is really being done) must ultimately pay; but if a man is broken in the process under the old theory of the "common law", his immediate family stood that loss. It may mean, summed up from the economic standpoint, that a man is worth two thousand, three thousand or four thousand dollars. That is what it costs to "produce" a mature workman, and it does not seem right that the man's family should stand the loss when he is "broken" or destroyed in an industrial process. It seems to me that it should be distributed over the product like any other item of producing cost, until the consumer, the man who gets the benefit of that work, pays for it. Then the loss through accidents will be studied and reduced to the lowest possible point, just as we try to keep down scrap and breakage. But as long as the individual family stands this loss and the manufacturer feels that he does not have to—it is not going to come home to him with the same force as a problem that he must work out.

American Machinist, Feb. 11, 1909.—Safety Devices in Machine Shops and Manufacturing Establishments.

————Feb. 18, 1909.—Safety Appliances in German Machine Shops. Illustrated descriptions of simple guards and operating devices to protect workmen.

Annals of American Academy, July, 1911.—Necessity for Safety Devices, by J. C. Delaney.

Cassier's Magazine, Aug., 1907.—Safety Appliances in the Engine Room, by W. W. Christie. With illustrations.

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————June, 1908.—The American Museum of Safety Devices, by H. T. Wade. Explains the purpose and economic value, giving an illustrated description of exhibits.

Illinois Steel Company—Specifications and Devices for Safety of Workmen On and About Machinery to Be Constructed and Installed, and Operating Conditions to Be Maintained at Its Plants. 1910.

Iron Age, July 13, 1911.—Standard of Safety in Relation to Machinery, by D. S. Beyer. Illustrated description of the system of the United States Steel Corporation, and the problems solved. Serial, first part.

Machinery, N. Y., Nov., 1911.—Safety Devices as Applied to Machine Tools, by Clarence Bolton. Illustrates and describes a number of single guards, which can be applied without great expense.

————Nov., 1911.—Accidents in the Machine Shop. Suggestions and rules for their prevention, collected from various sources.

Railway Age Gazette, Dec. 1, 1911.—Shop Safety Appliances and Safety Education, by George Bradshaw. Illustrates and describes devices and methods for securing safety, and discusses related matters.

Scientific American, Jan 26, 1907.—An Exposition of Safety Devices and Industrial Hygiene. Gives startling facts in regard to the great sacrifice of human life in industrial vocations and illustrates some of the safety devices exhibited at an exposition at the American Museum of Natural History, New York City.

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Symposium on the Automobile Motor

THE LONG-STROKE MOTOR

By J. B. Entz

The long-stroke engine is becoming increasingly popular, as being more powerful, flexible and economical than engines of equal volume, but shorter strokes. Some of the reasons for this may be seen from the following consideration:

A $4\frac{1}{2} \times 4\frac{1}{2}$ engine is of the same cylinder volume as a 4-inch bore by $5\frac{3}{4}$-inch stroke, but it has an area of piston head 26 per cent greater. If, during the working stroke, the pressure per square inch was the same in each case, the total pressure on the piston would be 26 per cent greater, but we would get no greater turning effort, as the crank on which it acts is proportionately shorter. The loss in the crank shaft bearings is, however, increased, due to the greater pressure on them, and the fact that the crank pins and main shaft bearings turn in their boxes, but once per revolution, whether the stroke be long or short. The side pressure of the pistons on the cylinder walls is also greater, due to the greater pressure on the larger piston head in the short-stroke motor.

The result is a higher mechanical efficiency for the long-stroke motor, as it has less internal friction. The piston weight and connecting rod weight is less in the long-stroke motor, due to the small size of the piston and less pressure on it.

The wall area of the compression space is less in the long-stroke motor, because of its shape, and the heat units lost are, therefore, less. The long-stroke motor has, therefore, a higher thermal or heat efficiency than the short-stroke, and, as the thermal efficiency is lowest at low speeds, the long-stroke motor pulls better at low speeds.

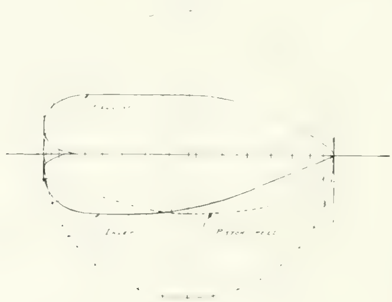
If the size and lift of the valves are made the same in each case, the volumetric efficiency of the two motors would be the same at the same number of revolutions per minute.

The extent to which the cylinder is filled on the suction stroke, is not determined by the speed of the gases in the cylinder, as they follow the piston on its down-stroke, but by the very much higher speed, they travel through the carburetor, inlet passages and valves, which is the same in the case of both engines. Also the rate of expansion of the gas on the working stroke after it has been ignited is not different in the two engines, as in each case the expansion is from the volume contained in the compression chamber to the total volume of the cylinder and this takes place in the same length of time at the same number of revolutions per minute. Also, the mechanical balance of the two engines is the same at the same speed, in revolutions per minute,

as the only two factors which determine the balance that are not the same in each engine are the weights of the piston and connecting rod and their linear speed, and the weight of these parts in the longer-stroke engine is less in the same proportion that their linear speed is higher.

The best relations of stroke to bore or most practical relations, according to the latest practice, in Europe and this country, is a stroke 1.4 to 1.5 bore, although engines have been built with a stroke more than twice the bore. It may be interesting to show how the valves open in relation to the position of the piston, and the piston speed at different points in the stroke, although this is not necessarily different in the long and short-stroke engine.

This is a card taken from an engine with an indicator made for that purpose. The exhaust valve opened 45 degrees before the piston reached the lower center, which in this case was ¾ inch on a 6½-inch stroke. It will be noticed that the piston movement is slowest around its lowest center, and the valve is half open, or more, at the lowest center or finish of the power stroke, although it does not commence to open until the power stroke



is practically finished. The exhaust valve opens very rapidly at first in relation to the piston movement, as it should do to permit the easy escape of the exhaust gases. The exhaust valve closes a little past the top center, about 5 degrees, which corresponds to a very small downward movement of the piston on the suction stroke. The inlet valve opens a few degrees after the exhaust closes, and as it opens after the piston passes the top center, its opening is not nearly so rapid in respect to piston movement as the opening of the exhaust valve, which starts before the lower center is reached.

This, however, does not matter much on the beginning of the suction stroke, as any vacuum resulting therefrom is useful later on in the stroke, when the valve is wide open. The inlet valve does not close at the end of the suction stroke, but is open for 35 degrees on the up or compression stroke. This keeps the valve half open at the finish of the stroke, and allows the air and gas, which has attained a high velocity, to enter and fill the cylinder, to a much greater degree than if the valve is closed at the end of the stroke.

The dotted line shows the piston speed at different points of the stroke. It is higher near the top center than the bottom center on account of the angularity of the connecting rod. It will be noticed that the inlet valve opening is smaller in proportion to the piston speed at the beginning of the suction stroke, than it is on the last part of the stroke, where it is wide open after the piston speed has commenced to decrease. This is as it should be, as although the piston movement is the actuating force that moves the air and draws it into the cylinder, yet the inertia of the air causes it to lag behind at the first part of the stroke and after it has obtained velocity and momentum, it continues to enter the cylinder even when the piston has reached the end of the stroke and for some distance on the upward stroke. The higher the speed of the engine, the more the advantage in the late closing of the inlet valve. But the closing shown is very good, as the valve is half open at the end of the stroke and is closed when the piston has moved ½ inch upward on the compression stroke, thus not permitting of much loss of the charge even at slow speeds.

The carburetor is a device by which the air drawn into the engine on the suction stroke picks up the proper amount of gasoline to combine with it. The theoretical amount of air to combine with the gasoline is about 15½ to 1 by weight, but in practice the usual mixtures are about 20 to 1.

As the vacuum in the carburetor is the force that acts upon both the gasoline and the air, and as the velocity which will be imparted to either is inversely as the square root of their mass or weight, it follows that as gasoline at 60 degrees Fahr. weighs about 580 times as much as air, at the same temperature, its velocity, when leaving the nozzle, is inversely as the square root of 580 or 1/24 the velocity of the air, in the tube around the nozzle.

So if we had a single gasoline nozzle, in a single air tube, through which all the air passed, and the air tube was 1 inch in diameter and the gasoline nozzle was 1/20 inch, then the quantity of air by weight compared with the gasoline would be first 400 times, because of 400 times the area, multiplied by 24 because of 24 times the speed, and divided by 580 because of 1/580 the weight. This gives 16½ as the ratio of air to gasoline by weight. As the gasoline leaves the nozzle, it becomes finally divided and is carried along with the air at an increasing speed until it reaches the same speed as the air, or until it combines with it to form gas. I mention this fact of the very much slower speed of the gasoline as compared to the air into which it first enters, as I find that many have an idea that the gasoline impinges upon the air like water from a nozzle upon stationary air.

Theoretically with a nozzle of a given size in a fixed sized air tube, we should get the same proportion of air and gasoline at all engine speeds and throttle openings. But in practice, this would give us a mixture too rich with wide open throttle and high speeds, and too weak when running slow and with nearly closed throttle, so that means are provided in all carburetors to add more gasoline at low speeds.

This is arranged in a large class of carburetors by means of

an auxiliary air opening which is closed by a spring-controlled valve; at high suctions, this opens and admits more air, and by proper adjustment of the spring tension, can be made to give the proper mixture at high suctions and low. The auxiliary air valve in some cases is seated by its own weight. Another class of carburetors closes up the air passage around or near the gasoline nozzle as the throttle is closed, so as to increase the velocity of the air at that point and thereby the proportion of gasoline. Another class of carburetor has a second nozzle which feeds gasoline into a small inverted "U" shape air passage, one end of which communicates with the main air passage and the other end of which communicates with the air outside the carburetor. This nozzle feeds under the influence of gravity, being placed on a level about 1½ inches below the float chamber level. When the engine is stopped, this auxiliary air passage fills up to the float chamber level, and when the engine is cranked adds an additional amount of gasoline, which is an aid in starting.

The gasoline fed from this second nozzle, is supposed to be constant, or nearly so, and independent of the suction, and to add the proper additional amount at low suctions.

Another class opens the air and gasoline passages simultaneously by a valve which acts upon each, and which is usually controlled by the suction in the carburetors. If these valves, the one acting upon the air and the other upon the gasoline, are properly proportioned, the proper mixture can be secured at each point.

It will be seen that the proper proportion of air and gasoline passages for different speeds and throttle openings are secured in two ways; one by the suction in the carburetor, and the other by the position of the throttle. The first, controlled by the suction in the carburetor, can be made to fit any desired mixture proportions for any suction resulting from the speed and throttle opening of the engine, but the same suction may result from an engine running at 500 revolutions per minute with the throttle wide open as when it is slowed down by the hard pull, and from an engine at 1,000 revolutions per minute with the throttle partly open as when running on a level road at a speed of 25 miles per hour. For the first condition we want the mixture that will give the engine its maximum power. For the second condition we want the mixture that will give the best economy, not power, as more power may be obtained simply by opening the throttle farther. The best economy is obtained by a mixture considerably weaker than that which gives the most power, and as the engine is run most of the time with a partly closed throttle, such carburetors are not as economical as they would be if the mixture were weakened when running with a partly closed throttle, as with the car running on the level at moderate speeds. With the class of carburetors in which the mixture is controlled by the position of the throttle very good economies can be secured, as it is possible to proportion the air opening affecting the gasoline flow for each throttle position so as to get the best economy for practical work. With a wide open throttle the relations of the air and gasoline passages remain fixed, however much the speed and suction changes. If the mixture is right for 1,500 revolutions

per minute, at about 500 it will be too weak and the engine will not pull well, and it will be necessary to change gears on a hard pull if the engine has been allowed to slow down too much.

For the reason that gasoline is much more expensive in Europe than in this country the last class of carburetors are most in use there, while in this country the first class described are mostly used, as there seems to be a greater objection to gear shifting and the engine that can pull hard at low speeds is much desired.

I have spoken of four general means of controlling the proportion of air and gasoline, but these means have been united in a great number of combinations, and more are appearing every day. There are also double carburetors; first one and then both being brought into use either by the movement of the throttle or by increasing suction in the carburetor. With the grade of gasoline we are getting now, heat is essential in cold weather, either by means of a water jacket or hot air.

The electric form of ignition is practically the only one in use today on automobile motors, and this is almost entirely the jump spark from high tension magnetos. Such magnetos are small dynamos with permanent steel magnets, whose output instead of being continuous like direct current dynamos or pulsating like alternating current dynamos, is concentrated so as to occur for an instant only at every half revolution of the armature. This output is at a very high voltage, capable of jumping in some cases a ½-inch gap. By means of a revolving brush making contact with segments that are connected by leads to the spark plugs in the different cylinders, the spark is made to occur in one cylinder after the other and in the proper firing order. The principle on which such a magneto works is as follows: The permanent field magnets establish magnetic lines of force through the iron of the armature, which are greatest in number when the armature lies parallel to the path between the pole pieces. As the armature turns until it stands at right angles to where it was before, the number of lines of force through its core diminishes to zero. If it is further turned 90 degrees more until it again lies in the path between the pole pieces the lines of force become maximum again, but in respect to the armature core in the reverse direction to what they were before. If a number of turns of wire were wound on the armature core and the ends connected to an outside circuit, we would have a simple alternating current dynamo, whose voltage for any given speed would be dependent upon the number of turns on the armature and the rate of change in the number of magnetic lines of force through the armature core, but the rate of change in the lines of force due to simply revolving the armature even with the greatest possible number of turns of wire wound upon it, is not sufficient to give so high a voltage as is necessary and it is necessary to elevate the voltage in some manner. This is done by winding a comparatively few number of turns on the armature and closing the ends of these by means of a contact maker at about the time the voltage wave commences to rise; this generates a current in the closed coil and this current magnetizes the armature core

still more increasing the number of lines of force in the armature core to more than would be forced through it by the magneto alone. At about the time the current in the closed circuit reaches a maximum the contact maker is opened by a cam, and as the circuit is instantly broken, the current falls to zero and the magnetic lines of force in the armature, due to this current, instantly disappear. This induces a voltage in any coil wound on the armature core which is very high in proportion to the number of turns, so that if we wind a second coil on the armature consisting of a great many turns of fine wire, we will get an instantaneous and very high voltage which by means of the distributer we take to the engine. As the spark occurs at the moment of opening the circuit breaker, the timing of the spark can be accomplished by moving the cam which opens the contact maker.

Instead of winding a second coil of a great many turns on the armature core, an induction coil may be used which has a primary winding of a few turns connected in circuit with a single winding of a few turns on the armature so that the current that is generated in the armature coil when the circuit maker is closed, also passes through the primary coil of the induction coil, magnetizing its core, and when the current is broken by the magneto circuit breaker, the high voltage is induced in the secondary of the induction coil and led to the distributer on the magneto and thence to the cylinders.

VALVE MECHANISMS

By Jas. G. Sterling

The subject of valve mechanisms is perhaps the wrong one for this paper since the time for its preparation and presentation would not be sufficient to cover so broad a subject.

The purpose of the paper will, therefore, be to briefly outline present practices and tendencies in the design of this feature of the automobile motor and to describe a few types of valve mechanism that are in use at present in four-cycle automobile motors.

At the risk of being too elementary it may be well to describe first the functioning of the valves in a four-cycle internal combustion engine and indicate the average timing for opening and closing the inlet and exhaust valves generally employed.

The four cycles, admission or suction, compression, explosion and exhaust, are accomplished in two revolutions of the main crank shaft.

The inlet valve opens when the piston is on top and is held open until the piston has completed its suction stroke and started back, closing when the crank has turned 30 degrees past the bottom center. The piston completes its compression stroke, the charge is fired and when the piston has traveled two-thirds down on the firing stroke, the exhaust valve opens at about 50 degrees before the bottom center on the crank circle and remains open

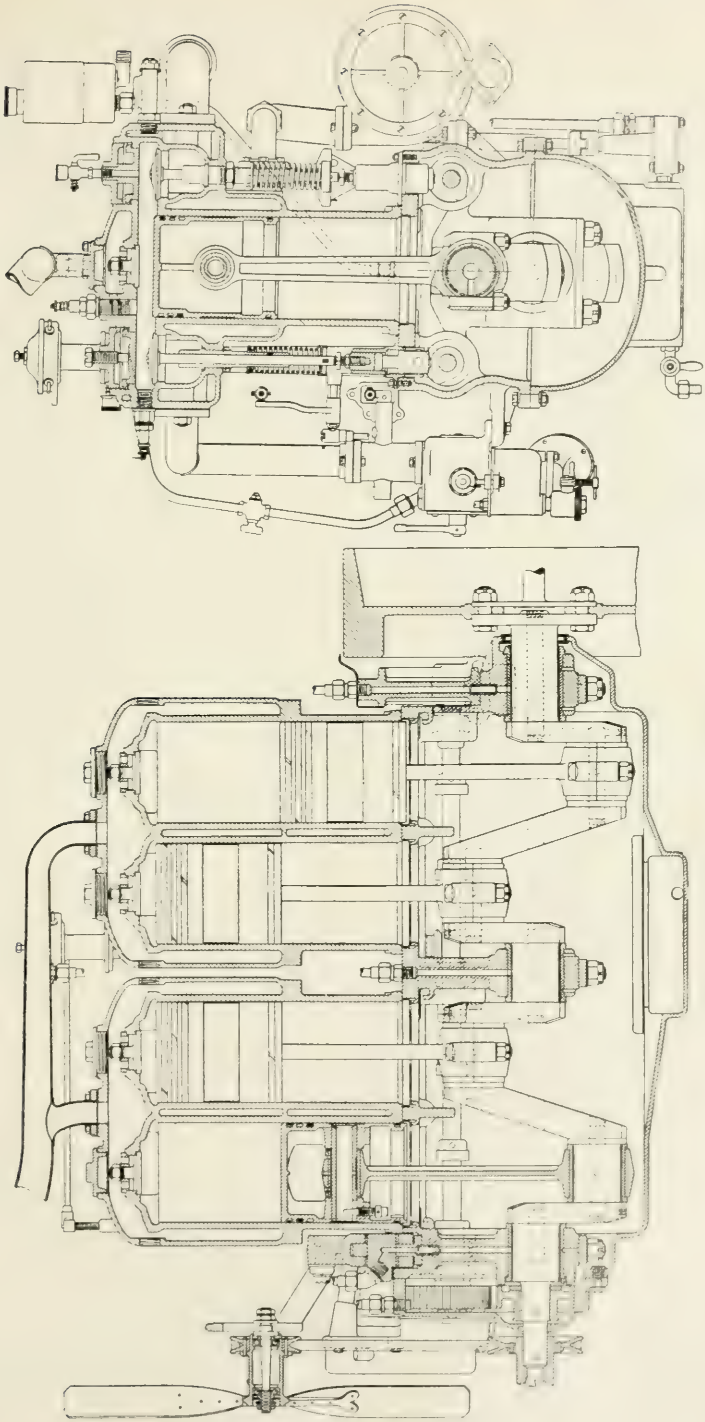


FIG. 1

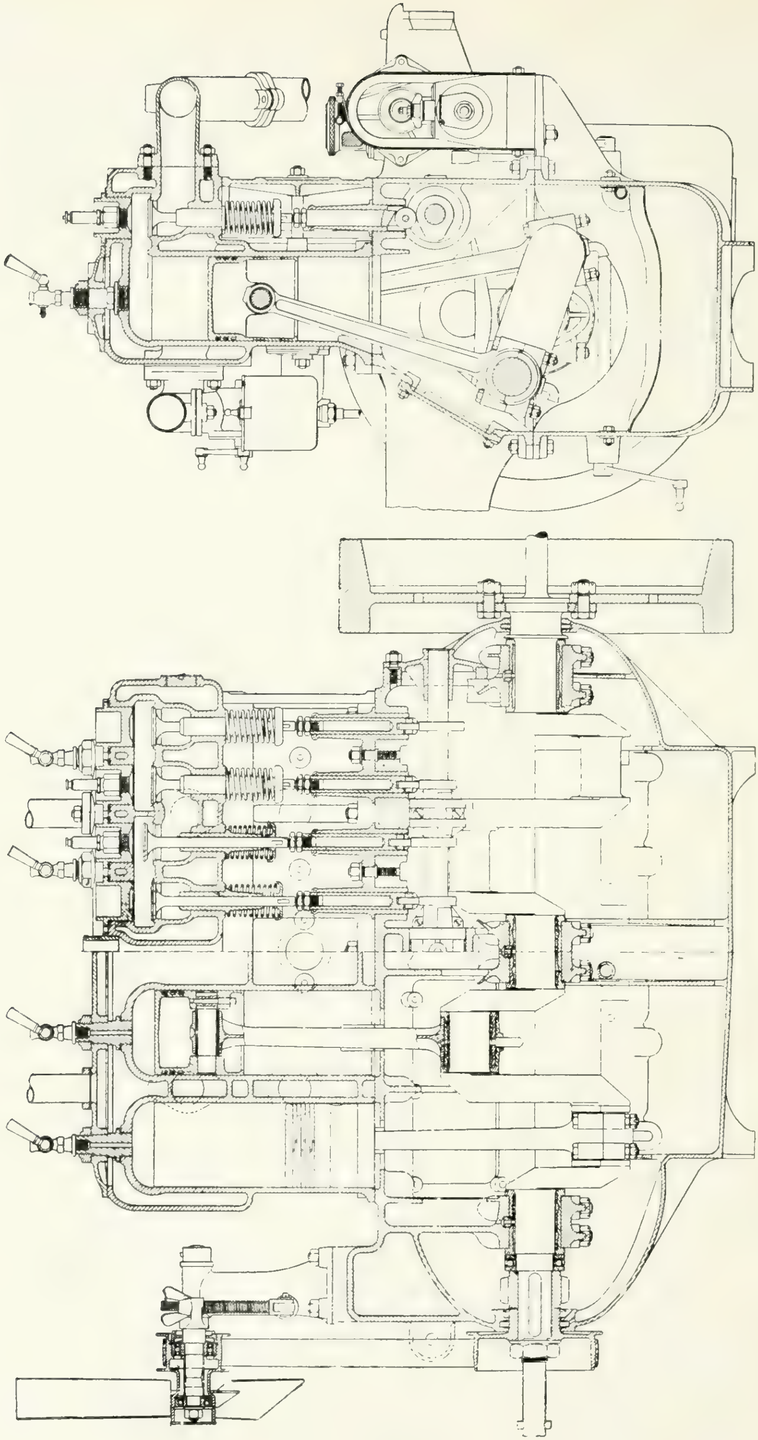


FIG. 2

until the piston has completed its exhaust stroke and is at the top again.

From the timing of the valves it is apparent that the automobile motor is perhaps best described as an internal explosion motor, getting its power from the impact of the explosion rather than from the expansion of the exploded gases. The purpose of the valves is, therefore, to admit as large an amount of gas as possible, to hold it while it is compressed and fired and to exhaust as quickly as possible the exploded gases.

The measure of the efficiency of a valve mechanism is the manner in which it performs these functions.

Theoretically this would mean a study of valve opening diagrams and determination of the intake and exhaust gas velocities, the power consumed in the operation of the mechanism, etc. Practically, however, the measure of the efficiency as it appears to the automobile builder is more closely allied to the durability, reliability, simplicity and ease of manufacture of the valve mechanism.

To these requisites during the last few years has been added "quietness of operation". At the present time it is one of the determining factors in the selection of valve mechanism and is perhaps the direct reason for the widespread interest in the Knight type engine and for the great amount of study and development now being applied to the valve mechanism of the automobile motor.

In the early development of the four-cycle engine, all the different forms of valves used in the steam engine were tried. Owing to the fact that it was extremely difficult to secure lubrication of a sliding or rotating surface under the heat to which these were exposed in an internal combustion engine, only such valves as were designed to lift from their seats in opening were found satisfactory.

Up to 1908 the only type of valve that was successfully used was the poppet valve and this type is the one now generally in use in automobile motors. Its construction and design are well known and easily understood. The valve is held on its seat by a spring, is lifted at the proper time by a cam and reseated by the spring. With this type of valve practically any desired valve area, rate of opening and timing may be obtained by varying the size of the valve and the shape of its cam and follower. There is little variety in the present designs of this type of valve. In some initial constructions the inlet valve was made to open automatically, but with hardly an exception, both valves are now operated mechanically. A variety of locations for these valves can be found and the detailed design of their operating mechanism varies somewhat.

The first illustration shows a few typical constructions in present use. In Fig. 1, the inlet and exhaust valves are located on opposite sides of the cylinder; a cam shaft on either side of the cylinder running at one-half engine speed operates these valves. This design of cylinder is known as a "T" head cylinder. An "L" head motor has both valves on the same side and but one cam shaft is required; such a cylinder is shown at Fig. 2.

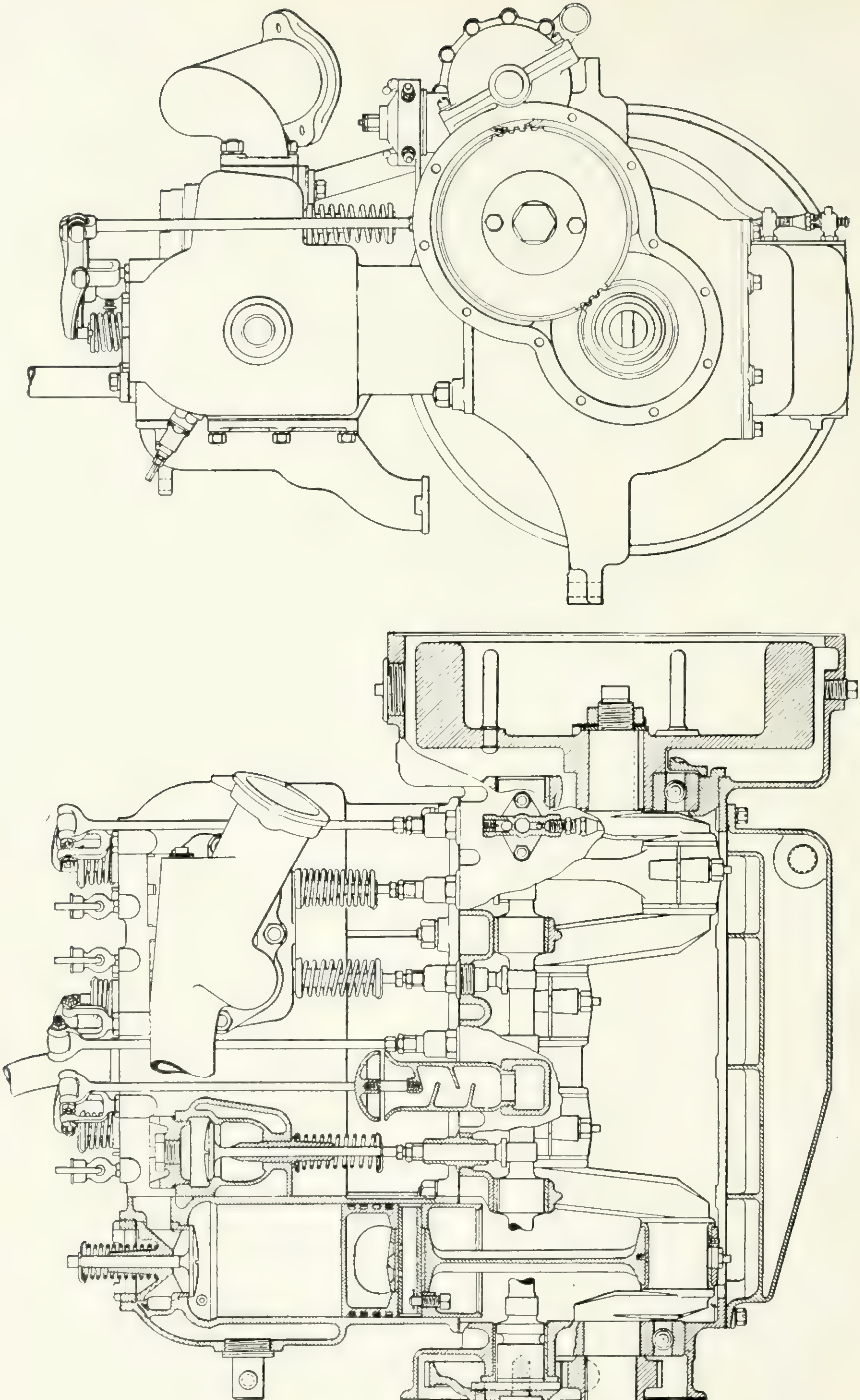


FIG. 3

In Fig. 3, the inlet valve is located in the top of the cylinder and the exhaust at the side. One cam shaft operates both these valves, a rocker arm serving to transmit the movement to the inlet valve.

In Fig. 4, an arrangement of both valves on top is shown. Both are operated from a cam shaft extending across the top of the cylinder.

In Fig. 5, the same location of valves is shown, but both are operated by the same cam. This construction was first used by the Fiat on a motor for a racing car and is interesting chiefly because of the operating mechanism.

It will be noticed that with the change in location of the

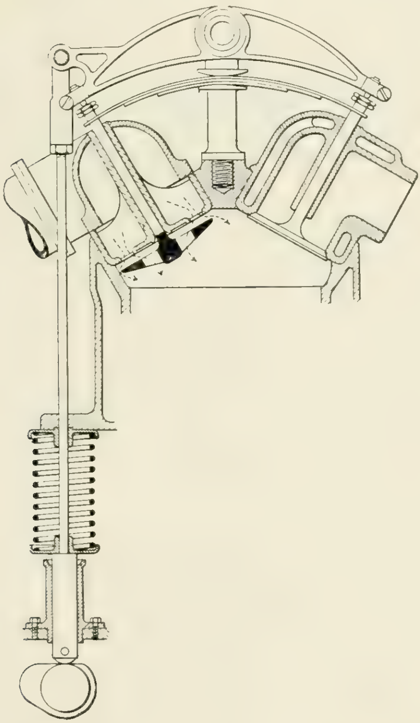


FIG. 5

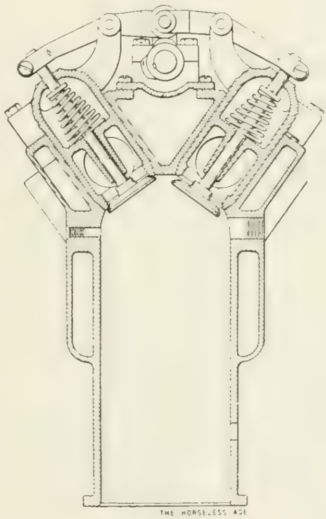


FIG. 4

valves goes a change in the shape of the combustion chamber of the motor, and of inlet and exhaust passages for the gases. What the designer is seeking is as near a spherical combustion chamber as possible; that is, one having the least surface area for a given volume. The most direct and unrestricted passages for the incoming and outgoing gases, without adding to the mechanical complication of valve operation, is also desired.

It would be difficult to select the best arrangement of the poppet valves shown or of many other arrangements possible. All of these serve their purpose well and the continued use of this type of valve mechanism is an indication of its reliability and success.

The operation of a poppet valve is, however, more or less noisy. Much of this noise can be eliminated by good workmanship, accurate adjustments and specially shaped cams and followers. The quietness gained in this way is more or less temporary, however, owing to the fact that the working parts will wear and the adjustments get out of order. The tendency toward the use of high speed motors has developed another imperfection in this type of valve mechanism, namely, the indefinite opening and closing of the valves at high speed. Tests have shown that there is not sufficient time for the spring to close the valve at high engine speeds. At high speeds, therefore, one would expect a loss of power from this defect in the functioning of the valves, due most-

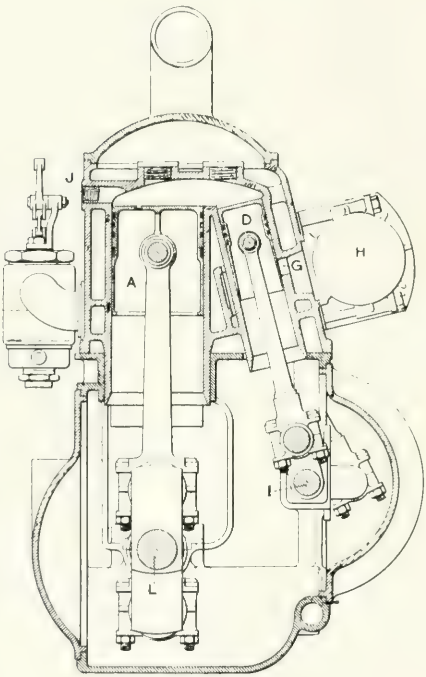


FIG. 6

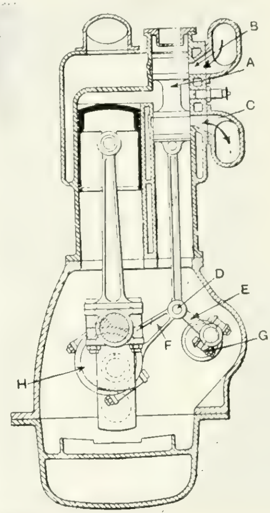


FIG. 7

ly to the exhaust valve holding open during a part of the suction stroke. This condition and the growing demand for silent operation has resulted in the production of many types of silent and positive valve mechanisms. A few of them have been built, fewer of them have been tested, and still fewer have been adopted by automobile builders.

In searching for a substitute for the poppet valve, perhaps the most obvious solution to the problem is the substitution of piston valves operated from an eccentric or small crank shaft in place of the cam operated poppet valves. Up to this time none of the many designs of this type which have been produced have been taken very seriously by automobile manufacturers. As a rule, these mechanisms consist of one or more pistons reciprocated

INTAKE COMPRESSION EXPLOSION EXHAUST

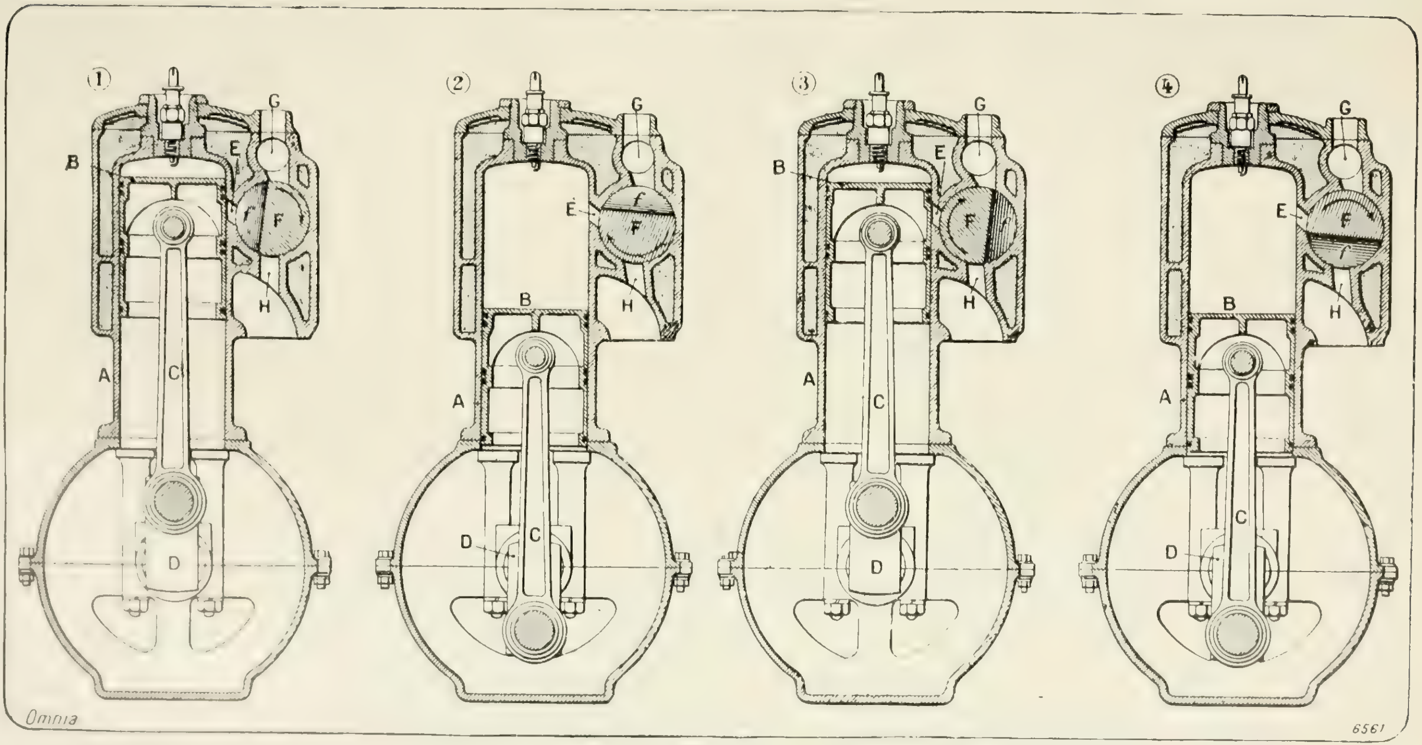


FIG. 8

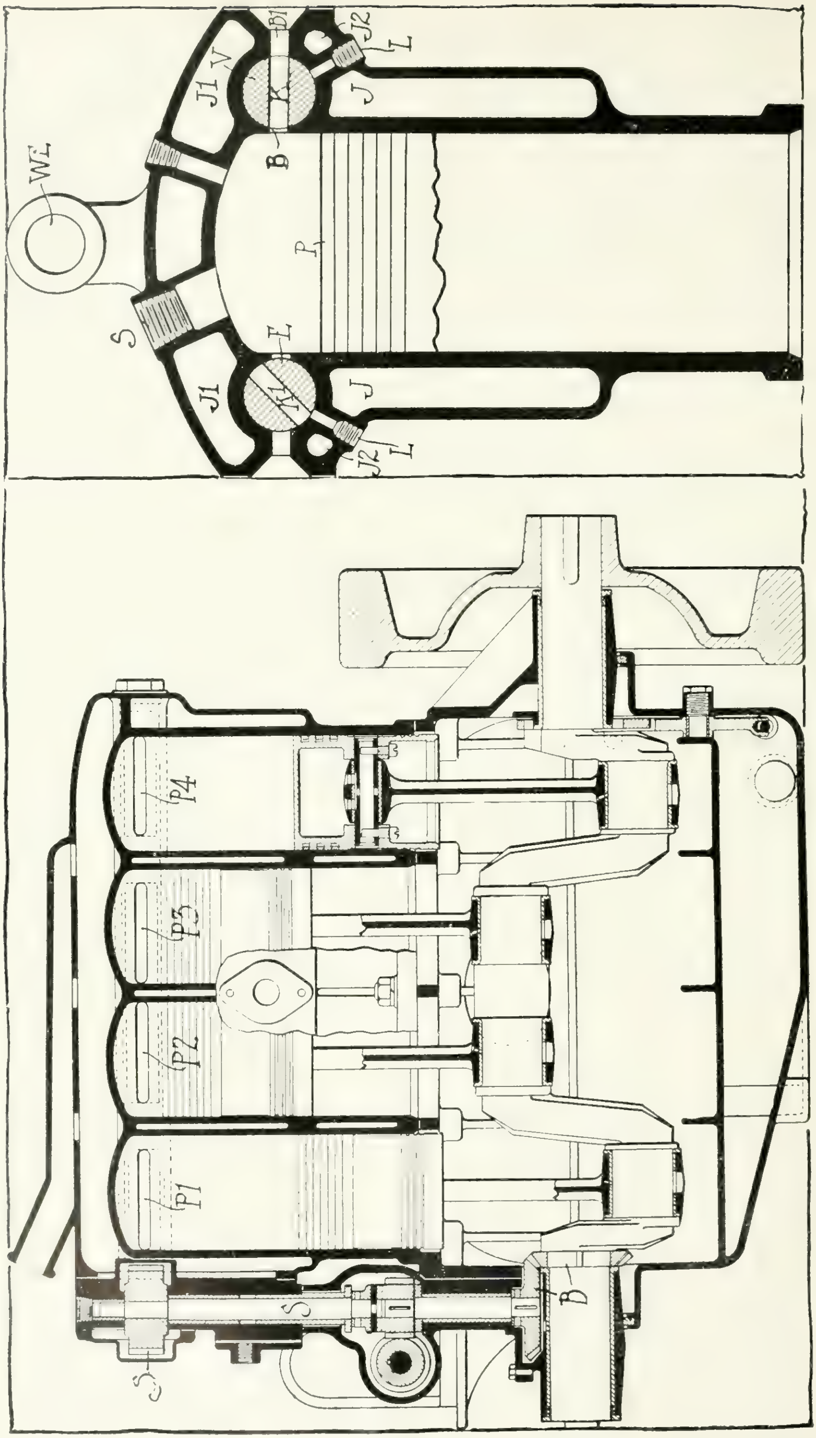


FIG. 9

in a valve cylinder, into which ports from the working cylinder have been cut. These ports are covered and uncovered by the piston valve during the desired period of valve opening. The location of the valve cylinder with reference to the main cylinder varies in these designs from a location at the side of the main cylinder and parallel to it to a location at the top of the cylinder with the piston valve traveling at right angles to the main cylinder. These valves are made gas tight by the use of spring rings or without them depending more or less upon the faith of the individual designer.

The illustrations will show only a few of the many designs of this type of mechanism now being considered.

Fig. 6 is what is known as the Hewitt engine and shows the substitution of two piston valves for the ordinary poppet valves.

Fig. 7 shows a type of piston valve which is particularly interesting because of the method of operating the single piston valve. The inlet port is at the top, and the exhaust at the bottom. Since the opening of the inlet must follow immediately the closing of the exhaust and both remain closed during the compression and firing strokes of the main piston, it is necessary for the piston valve to move very quickly from its lowest to its highest position during one revolution of the main crank and to dwell or remain practically stationary at the position shown during the next revolution.

The linkage gives this travel to the piston without the use of cam or springs. The shaft "G" runs at one-half engine speed. The mechanism is patented by the Wolseley Co., of England, but is not being used in their standard cars.

In this connection it is interesting to note that the original Knight sleeve valve engine contemplated the use of some such linkage in operating a single sleeve and a few motors were built this way. The limitations of such a valve mechanism are obvious.

Another more or less obvious solution of a quiet and positive valve action is that of the rotary valve, and many patents on this type have been taken out by designers.

The failure of this type of valve construction on stationary engine designs have in the past deterred the automobile builder from trying it out on automobile motors. Of late, however, a number of valve designs of this type have been described in the automobile trade papers and one or two of them are now on the market. One of the simplest forms of this valve is that adopted by the Darracq Co., and was patented by a Frenchman named Henroid.

It consists of a cylindrical shaft or sleeve driven at half the speed of the main shaft and located at one side of the en bloc cast cylinders. A semi-circular notch or port is cut in this sleeve opposite each cylinder and, as the sleeve is rotated, alternately connects the cylinder with the inlet and exhaust ports. By a proper location of these ports the desired timing is effected. In Fig. 8 the four section views of a cylinder show the positions of the valve shaft at the various points in the cycle of operation. The simplicity of the mechanism is apparent, but a consideration of the practicability of its use in an internal combustion engine would

suggest a difficulty in keeping valve tight, in the conditions under which it would have to be used.

This valve or distributing shaft is not carried directly in the casing or portion of cylinder casting in which it revolves, but is supported at each end on a ball bearing, and the clearance between the valve and its casing is said to be about 1/20 of a millimeter.

The valves are made gas tight, as stated in the makers' catalog, owing to a circular joint of an ideal plasticity which covers the whole surface of the sleeve and revolves with it. Just how this oil film, which is perhaps what is meant is maintained, and what effect the alternate heating and cooling of the valve by the exhaust and inlet gases would have on it is not apparent. It is interesting to note that the valve shaft is located below the top of the piston travel and that the port into the cylinder is more or less sealed by the piston when at the top of its stroke.

The Darracq Co. is an old and well known French company, and many of these engines are now being manufactured. One of these was exhibited at the late New York show.

An American production with somewhat similar valve construction is known as a Meade rotary valve motor, and is manufactured by the Meade Engine Co., Dayton, O.

Fig. 9 shows a four-cylinder motor of this make, in which two valve shafts extend along opposite sides of the en bloc cylinder casting. Long, narrow slots in these valve shafts register with ports of equal length and width in the cylinder. These valve shafts are driven at one-fourth the speed of the main crank shaft. One of them serves for the inlet valve and the other serves for the exhaust valves. The shafts are of cast iron and are cooled by the water jacketting of the cylinder. The shafts take their bearing directly on the cylinder casting, and are lubricated by the forced introduction of oil at points between the cylinders and at the ends. The clearance between the shaft diameter and the bore of its casing, is said to be one and one-half thousandths except at the points through which the ports of slots are cut, and for this distance the valve is relieved a trifle more. No effort is made to seal these valves other than by the fit between the surfaces. Being rotated at but one-fourth the engine speed, the rotative speed of these shafts is comparatively low even at high engine speeds. Fig. 10 shows one of the valve shafts of this engine. Numerous and satisfactory tests are said to have been made with these engines, but up to the present time the motor has not been adopted by any of the American automobile manufacturers.

A very different type of rotary valve is shown in Fig. 11. This valve consists of a flat disc seating inside the cylinder head. An opening in the damper-like disc is made to register with the inlet and exhaust ports in the cylinder casting above it. The disc is rotated by a vertical shaft extending upward through the center of the cylinder, and is driven by a spur gear at one engine speed. The illustration shows the general location of this disc, and the general arrangement of the operating mechanism. The shape of the opening in the disc is shown, which is also the shape of the ports in the cylinder casting. A very direct passage for the in-

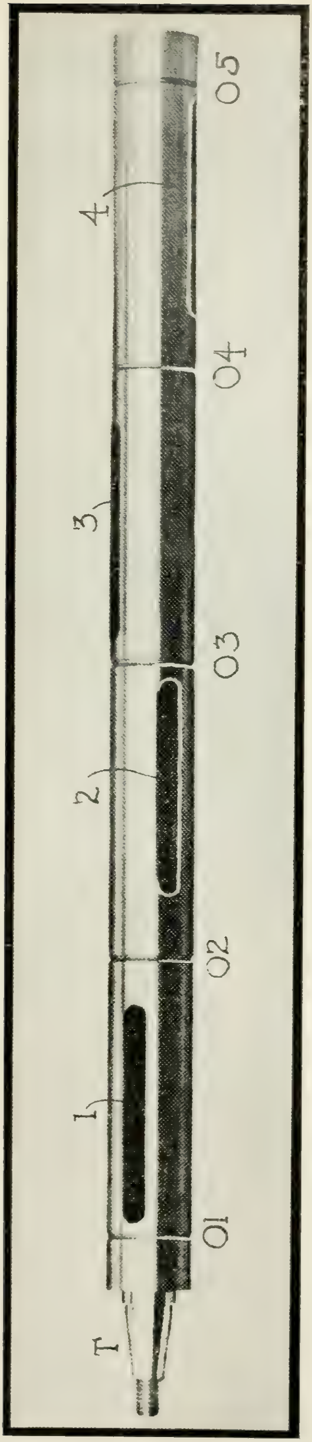


FIG. 10

coming and outgoing gases is provided.

Fig. 12 shows views looking down on the top of the motor, and up through the cylinders.

It would seem that the action of the valve would be at a disadvantage owing to its entire exposure to the heat and pressure of the explosion, and the fact that it would be very difficult to maintain any lubrication between the disc and its seat. Trouble from this cause is said to be avoided by careful water jacketing of the heads, and proper lubrication of the valves by a forced feed system. This motor is known as the Reynolds motor, and is manufactured by the Reynolds Engine Co., Detroit.

Many variations of the damper-like valves are being tried out. In one construction the valve is located in the same place, but conical in shape, a larger port opening being possible in this construction for a given size of cylinder. Still another type shows two discs, one on top of the other, but driven independent of one another, and in opposite directions.

A type of valve mechanism, which combines both the rotary and reciprocating motions, is shown in Fig. 13.

The Argyll motor, shown here, is an English design that was exhibited at the last Olympic show in London, and is being supplied in Argyll cars, manufactured by the Argyll Co., Ltd., Glasgow, Scotland. It has been favorably commented upon by the English trade papers, and to say the least, is a very ingenious design. Its valve mechanism consists of a single sleeve concentric with the piston, which is rotated slightly while being given a sliding up and down motion, a point on the surface of the sleeve passing through an elliptical path. This motion is given to the sleeve by a mechanism which is hard to describe without reference to the illustration.

The gear, *B*, is revolved at one-half engine speed. The axis of this gear is in line with the center line of the sleeve, but at right angles to it, a pin acting

as a crank, but held in the sleeve by a vertical pivot, raises and lowers the sleeve as the gear revolves and at the same time gives to the sleeve a rotary action, the pin sliding in and out of the gear to permit this movement. Certain ports in the sleeve are made to register at the proper time with inlet and exhaust ports in the cylinder. The construction of the sleeve, the cylinder and the cylinder head is not unlike that of the Knight motor, and these parts of the motor are shown in the illustration. The irregular shape of the ports, together with the combined rotary and reciprocating motion of the sleeves,

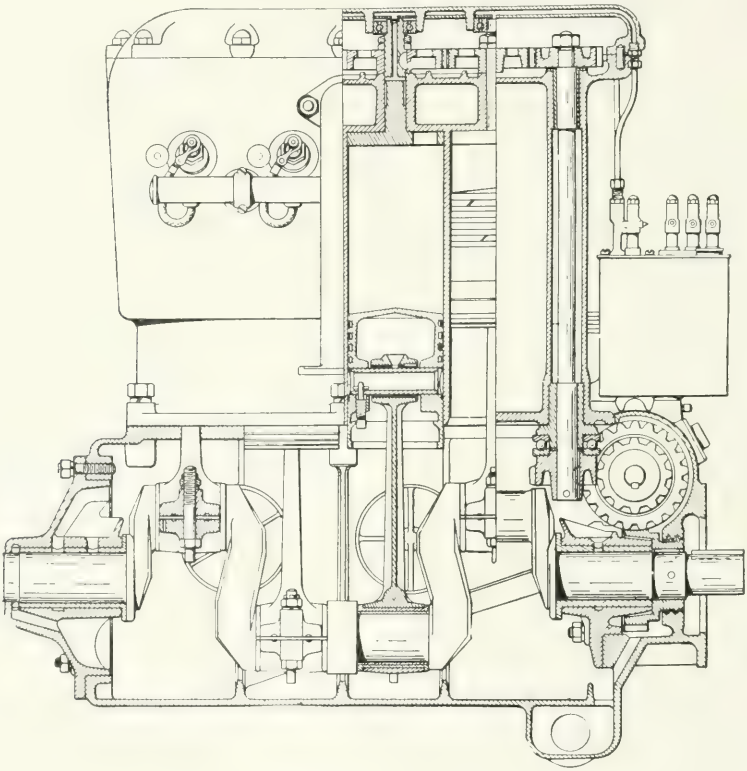


FIG. 11

give an interesting valve diagram, an unusually quick opening and closing of exhaust and inlet ports being claimed for this mechanism. It is said that no trouble is experienced from lubricating and cooling the valve mechanism, and that the lapping motion of the sleeve materially assists in its lubrication.

Fig. 14 shows the sleeve and some of its operating parts.

So far as known, no concerns other than the Argyll Co. are using this valve mechanism, although considerable effort is being made to market licenses for its use.

The next and last valve mechanism to be described is that invented by Charles Y. Knight. It is the first of the so-called

silent valve mechanisms, to be adopted by automobile builders, and up to the present time is the only type to be adopted by other than the original makers. Designed by Mr. Knight and originally incorporated in a motor known as the Silent Knight, manufactured in a small way in Chicago, this type of valve mechanism was adopted in 1908 by the Daimler Motor Co., of England. It has since been adopted by the Panhard Co., of France, the Mercedes Co., of Germany, and the Minerva Co., of Belgium, and the Russell Co., of Canada.

In this country, the Knight valve mechanism is being used by the Stearns, Columbia, Stoddard, Dayton and Atlas companies.

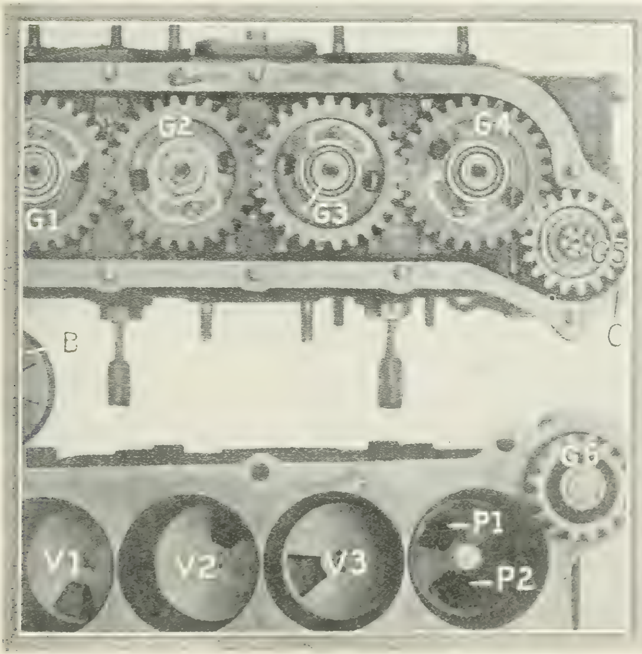


FIG. 12

The illustrations show the application of this valve mechanism to a Stearns-Knight motor.

The Knight valve mechanism consists of two concentric sleeves sliding up and down between the walls of the piston and cylinder. Certain slots in these sleeves register with one another, and with inlet and exhaust ports in the cylinder at proper intervals, to give the desired valve functioning.

Fig. 15 shows a cross-section through the center line of one of the cylinders, and shows the construction of the cylinder, sleeves and head.

It will be noted that the two sleeves are operated independently by small connecting rods, working from an eccentric or small crank shaft running lengthwise of the motor. This eccentric shaft is positively driven by a silent chain at one-half the speed

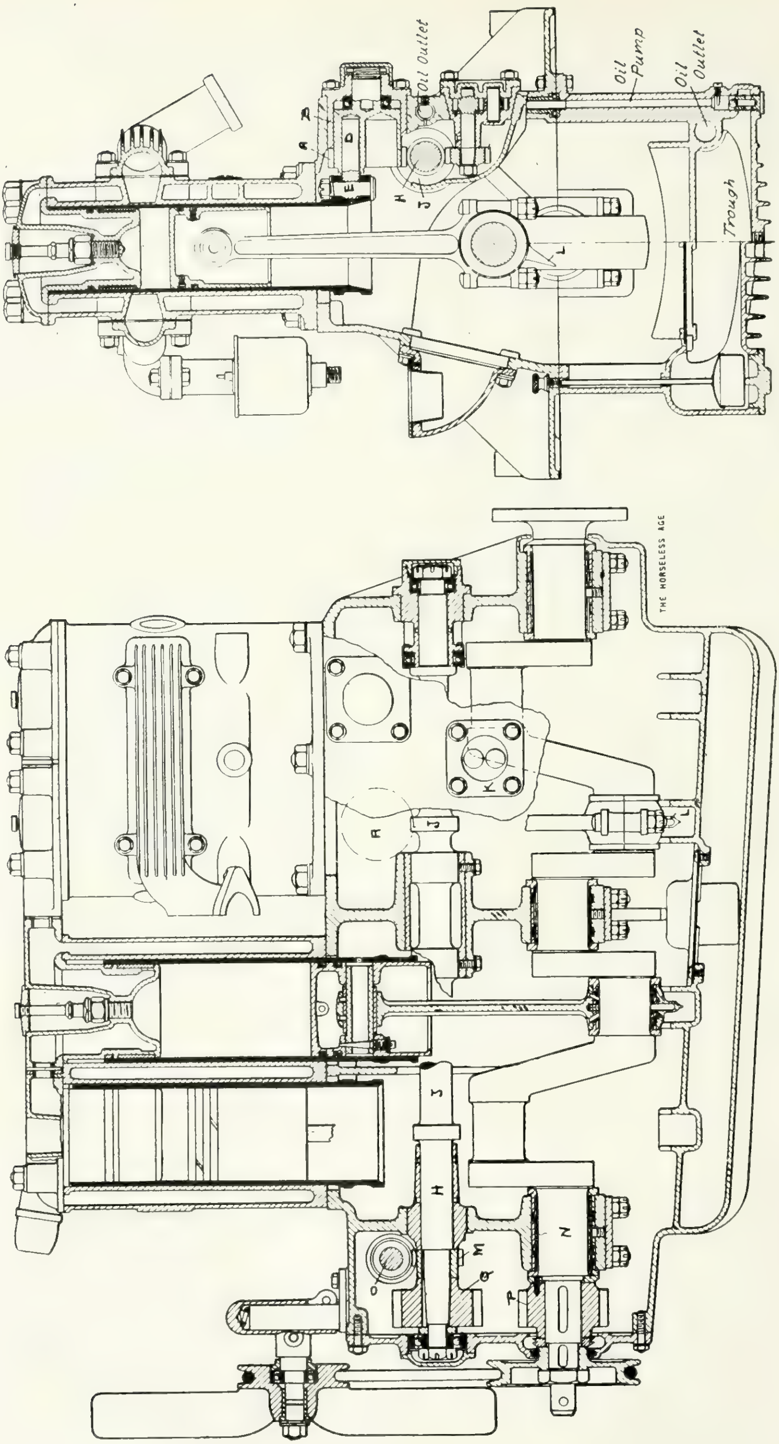


FIG. 13

of the crank shaft. The eccentric pin operating the inner sleeve is given a certain lead or advance over that operating the outer sleeve. The movement of these sleeves can best be seen in Fig. 16. Here the various positions of the sleeves during two complete revolutions of the crank shaft, are shown by the seven diagrams.

In the first diagram the piston is just past its top center, and is starting down on its inlet stroke. The inner sleeve is at the bottom of its travel and moving slowly upward, the outer sleeve is about midway in its travel and is moving downward rapidly. The opening from the carbureter through the inlet port into the

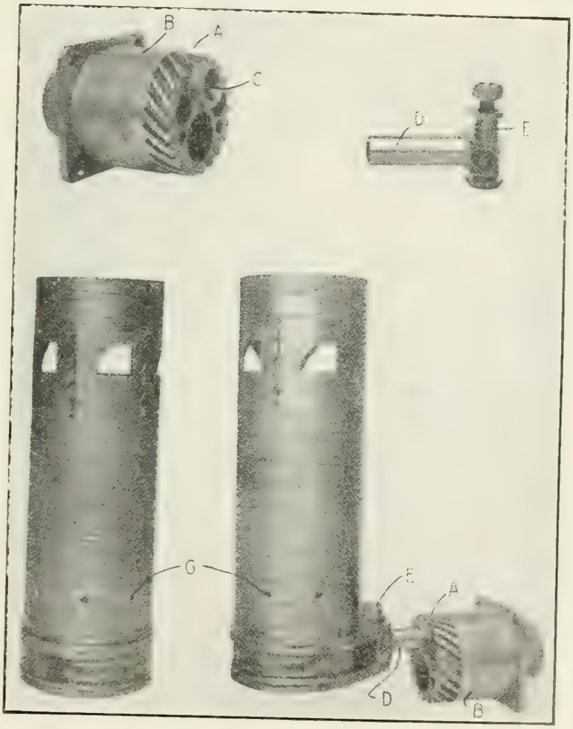


FIG. 14

cylinder is a rapidly increasing space between the upper edge of the slot in the inner sleeve and the lower edge of the slot in the outer sleeve. By the time the piston is a little more than half way down on the suction stroke, the inlet passage is wide open, as shown in the second diagram. The outer sleeve is now at the bottom of its stroke and moving very slowly, the inner sleeve is gaining in speed moving upward, and the inlet is closed by the lower edge of the inner sleeve slot in passing the lower edge of the junk ring, as shown in the third diagram. The inner sleeve continues to move up with the piston on its compression stroke, the rings in the head and piston tightly sealing the compression space, until the explosion occurs. The sleeves and piston are

then in position shown in the fourth diagram. About two-thirds of the way down on the explosion stroke of the motor the exhaust passage begins to open. The inner sleeve is moving down with the piston, and the passage is between the lower edge of the inner sleeve slot and the lower edge of the junk-ring in the head, the outer sleeve being practically stationary at the top of its stroke. The outer sleeve starts on its downward stroke, and, gaining in speed as the inner loses, leaves a clear opening for the

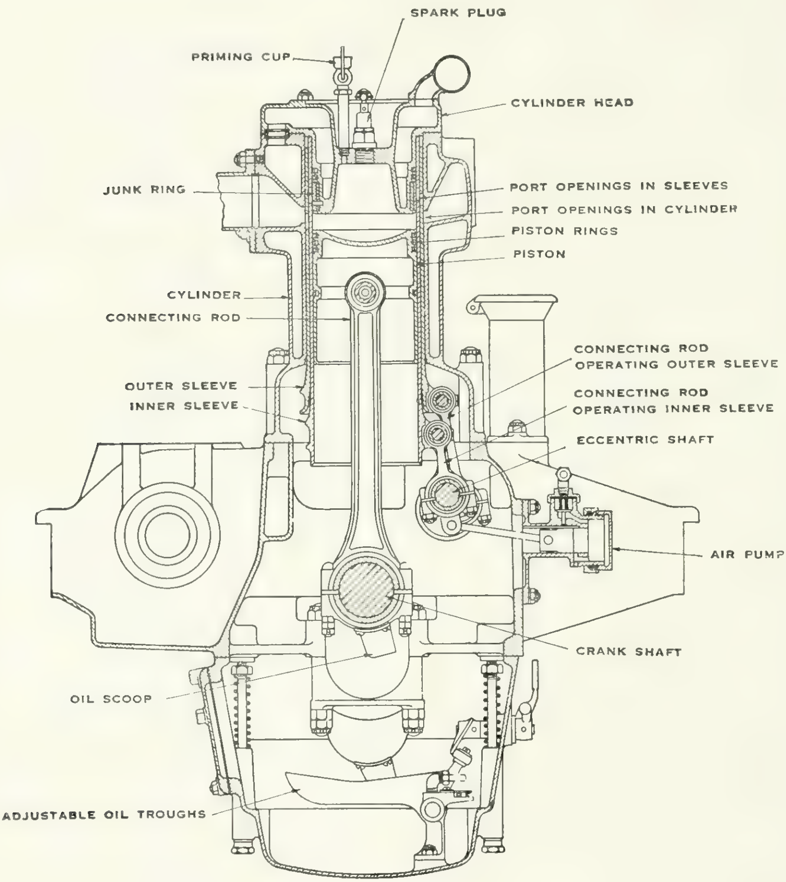


FIG. 15

exhaust. The piston is now one-third up on its exhaust stroke, and the passage is closed by the upper edge of the outer sleeve slot in passing the lower edge of the exhaust port in the cylinder, as the piston reaches its top center. The four cycles or strokes of the engine (suction, compression, explosion and exhaust) have now been completed; the crank has turned twice; the eccentrics have driven the sleeves once, and the cycle of operation is now ready to be repeated.

The timing shown is not different from that ordinarily used

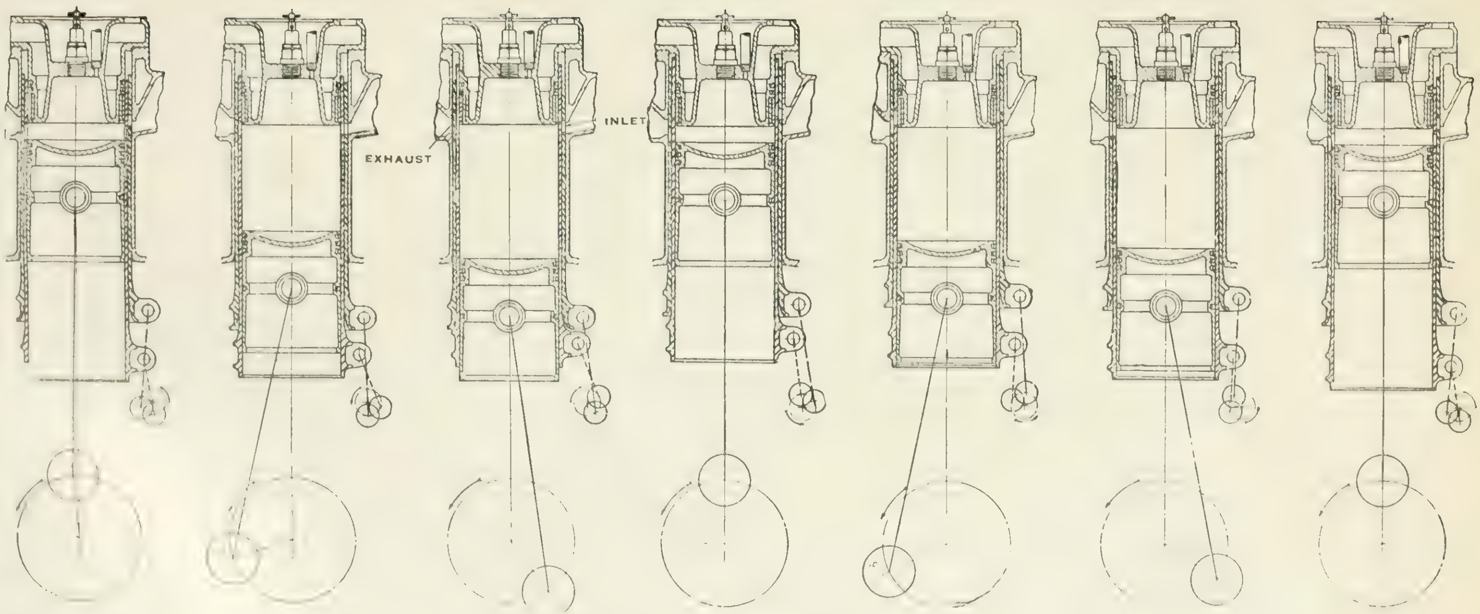


FIG. 16

in poppet valve engines. Any timing of the valves can be secured, however, by varying the "lead" between the eccentrics that operate the two sleeves and by properly locating the slot in the sleeves. The amount of valve opening is practically unlimited and is governed by the width of slot in the sleeves and the "throw" of the eccentrics that drive and determine the travel of the sleeves.

The valve area need not be much greater than that of a poppet valve. The equivalent of increased valve area is gained, however, by the directness of the valve openings and the absence of restrictions in the gas passages made possible by this construction.

The fourth diagram of Fig. 16 shows that the compression space is contained entirely within the inner sleeve and that the fit or clearance between the sleeves has no effect either on the amount of the compression or upon the tightness of the compres-

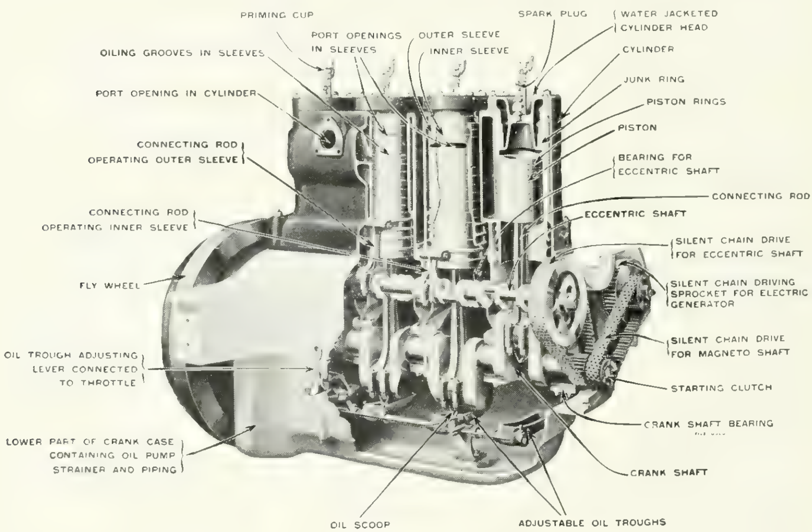


FIG. 17

sion space. The diagram also shows the general shape of the combustion chamber. It is evident that a minimum amount of surface is presented for the volume contained, so that the ideal spherical shape desired in gasoline motors is approximated.

The simplicity of the entire valve mechanism is apparent. The number of parts are few. All the working surfaces are cylindrical. The bearing surfaces are large and easily fitted, and with a fair amount of lubrication should last indefinitely. The operation and movement of the parts present no new principle in mechanics.

The operation of these sleeve valves is absolutely quiet, accurate, efficient, and absolutely the same at all speeds of the engine.

Fig. 17 shows the general arrangement and structural features of a Stearns-Knight motor. It varies in design from the other

motors using the Knight type of valves in detail only. The lubrication and cooling devices are not different from those in poppet valve motors.

The Knight type of valve mechanism is described in more detail both because definite information is available and because of its prominence in the automobile industry at the present time.

It is sure that further development along some of the lines indicated is possible. What has already been accomplished by Knight has concentrated the attention of designers upon the valve mechanism of the automobile motor. In their search for quietness efficiency has been found far in excess of that possible with the old type of valve mechanism.

The results so far obtained are but an illustration of the old adage that a cam and a spring are the last resort of a designer and that noise in any mechanism is but an evidence of inefficiency.

MOTOR-STARTING DEVICES

By Harold B. Anderson

Starters have become such an element in the sale of cars and also the conversation of the neophyte, that one is almost led to believe them of recent invention.

The necessity for a motor-starting device has undoubtedly been forcibly impressed upon the minds of all early investigators of internal combustion motors. Inventors and experimenters considered the ultimate to have been attained when finally they made their motors run, overlooking, possibly, that they had been cranked a sufficient number of times previously to amount to days of operation. It has been said that brakes on pioneer automobiles were an afterthought, for standing still almost all the time, the necessity for further assistance to this end was not apparent. Thus, the brake or stopper, long preceded the starter.

"Starter" and "self-starter" have, through public acceptance, been applied to all devices that assist in the process of getting the motor under way, and may be divided into two general classes—*kinetic* starters and *potential* starters. Kinetic devices owe their development to engineers, while those of the potential type owe their existence principally to the fact that the addition of water to calcium carbide forms acetylene gas. This gas was first isolated by Prof. Edward Davy in 1836 and called Klumene.

Kinetic starters, by various and diverse means, produce rotation of the crank shaft, depending upon the motor functions to succeed such action. They assume that a combustible gasoline mixture will enter the cylinder and be ignited during the resultant motion. Such mechanisms are *cranking* devices and not starters, whether electrically, mechanically or manually operated.

Potential starters depend upon having present, or placing in

the cylinders, a combustible mixture of some hydro carbon and air, then in common parlance to "start on the spark". They are *priming* devices only and depend upon ignition to start, and carburization to follow immediately.

A started motor assumes three things as having occurred—rotation of the crank shaft, proper carburization and ignition of the charges. Eliminating any one element precludes a started motor, and for that reason it is asserted that the classification of *cranking* devices and *priming* devices is correct.

As long ago as 1899, stationary engines were equipped with a hand pump to force a charge into the engine cylinder. This was fired by striking a rod which ignited a match in the cylinder. Charter, in 1892, received a patent upon a gasoline pump starter. Ignition of gun powder by an electric spark was patented in 1899, and 12-gauge, 300-grain cartridges were used by the Wolseley Co. in England in 1904, to start large motors. The spring engine starter is recorded in the Patent Office in 1900, while electric motor and compressed air devices were old at this time.

Quite a diversity exists in manually operated mechanisms. We have the well known starting crank and various forms of ratchet movements operated from the driver's seat, either by hand, or by foot pressure to intermittently actuate the crank shaft.

At the Paris Salon, in 1905, there were several "self-starters" displayed. The Societe Mors exhibited one consisting of a hand pump, which in operation forced a gasoline mixture into the cylinders and was afterward "started on the spark". The crank was entirely omitted, but was undoubtedly within easy access.

Cornilleau and St. Beuve displayed a ratchet, connected to a helical spline on the clutch shaft, which at each movement of the clutch pedal, turned the motor about one-eighth of a revolution. De Deitrich was equipped with the Letombe device, consisting of a small air compressor used to charge a tank and having on its shaft a distributor valve synchronized with the motor so as to properly admit air successively to each of the four cylinders on its firing stroke. Saurer also showed a similar air starter. Brasier had a hand mechanism, operated by the pulling of a cable attached to a ratchet for cranking the motor. Renault had a rack and pinion, operated by a two-cylinder opposed engine starter called the Cinogene, actuated by an 800-pound pressure tank of carbonic acid gas. Henri Pieper displayed a gasoline-electric vehicle (called the Auto-Mixte) with a storage battery, which accomplished the starting electrically, using storage battery current to operate the motor-generator set as a motor to start, and after starting, to recharge the batteries and also operate an electric motor that culminated the drive to the rear wheels. In Paris, during the December Show of 1903, the Compagnie de l' Industrie Electrique, of Geneva, also presented such a combination.

At the Chicago Automobile Show in 1906, the Harrison car exhibited a device for "starting on the spark" after previously admitting acetylene into the cylinders.

The foregoing indicates that as the general ideas involved in all the present day starters are old, acceptance is due to their development rather than anticipation or invention.

Two general types of air starters are in use, those admitting air to the internal combustion motor cylinders to produce motion and those providing a separate air motor for this purpose. The latter type has not generally proven satisfactory, inasmuch as while acting as a compressor, its ratio to motor speed is about 1/5, while, as an air motor, the ratio must be more nearly 10/1, to crank the engine. Renault in Europe, and several in America, attempted such a device with a gear change mechanism to obtain these ratios.

Until the Winton motor of 1907, an air starter of the former type was not a success, inasmuch as in this system, where the engine piston receives the pressure, the air must necessarily be admitted on the firing stroke, and cut off previous to the exhaust valve opening. The exhaust valve opens approximately 45 degrees previous to the stroke completion and the flywheel would not carry over the other 45 degrees on four-cylinder motors. Pipes of greater capacity were used to accomplish the acceleration more rapidly so that the flywheel could carry over the interval until the next cylinder was under air pressure. The main difficulty was that at the time the air was cut off, another cylinder was reaching its maximum of compression. Chalmers and others building four-cylinder cars, for this reason provide a relief port in the air distributor communicating with the atmosphere. With a six-cylinder motor, where ignition and other duplicated functions succeed each other every 120 degrees, we find that it is possible to have air pressure upon two pistons at one time, which assures a continuous crank shaft rotation until the air supply is exhausted. Thirty pounds will rotate the motor and only 10 pounds is a very great assistance if the crank is to be used. Air is obtained in two ways, either by a compressor or by taking off part of the gas at the time of ignition. The first method entails a clutch operated mechanism to disconnect the compressor when the tank pressure is sufficient (an unloading intake not being equal to the occasion) to relieve the pump. By this method, pressure can be obtained up to full tank, while the car is stationary. The second method of taking pressure from the cylinders cannot put as great a pressure in the tank as is obtaining in the cylinder at the time. Its means to charge the tank is simply a cylinder exit check valve with a pipe connected to the accumulator or tank. At each ignition, a small volume under pressure enters the tank and is retained. Running idle, 30 pounds is normally produced, but by proper manipulation, it will reach 80 pounds. Under motor load, 200 pounds may be obtained.

The intake to the individual cylinders is either an inpassage check in each line from the synchronized distributor valve or a positively operated valve in each cylinder, simultaneously opened during the synchronized distributor air admission. The latter type must be used together with compression release on four-cylinder motors, as the air must pass in both directions, which precludes the use of a check valve. In air starters, the air must be admitted just after the piston is over the upper center. All air starters will function more certainly if the spark is advanced just enough

so as to ignite the charge previous to the air admission, inasmuch as the actuating cylinder has previously performed the functions of suction through the carbureter, and the compression of the charge. The admission of fresh air or spent gas previous to ignition would dilute the contained mixture and impair its efficiency as a combustible.

Early Starters

In stationary work, early motors were equipped with half compression cams and the air inlet valve to start the engine was timed by a hand operated lever, as was the first steam engine valve gear.

Previous to 1900, Hornsby Akyroyd used a hand pump to fill a tank and then allowed the accumulated tank pressure to start the motor, avoiding the use of a power compressor.

Fielding used the motor, as it was stopped to act as an air compressor to charge a tank, for the purpose of starting.

Lanchester and Green utilized a flame starter. After charging the cylinder with gas and air, an outside flame fired back into the cylinder through a small orifice, ignition instantly following. The piston area being so much greater than that of the small orifice, motion ensued in spite of leakage.

Stockport in 1882, admitted gas to a hot tube, which produced self-ignition of the charge and resulted in motion to the crank shaft.

Tangye admitted a combustible charge to the cylinder, placed the crank shaft in motion and then ignited the contained mixture.

Electrical Starters

Electrical starters consist of an unit dynamo-motor, driven by the engine and in circuit with a storage battery. While the engine is in operation, the batteries are being charged and also current for electric lights and ignition is supplied. To start the engine, the battery operates the combined instrument as a motor and cranks until the engine follows its natural functions.

Some mechanisms of this type contain a sufficient number of clutches, gear change mechanisms, recording meters, indicating meters, and complicated circuits to baffle a session of mechanical and electrical engineers, in the solution of trouble.

The White electrical starter exemplifies a very simple and complete solution of the problem, inasmuch as a reversal of armature rotation, assemblage of meters, and other laboratory apparatus is entirely eliminated. All that is necessary to observe is that the battery condition conforms to the hydrometer standard, which is to be occasionally tested. The electrical starter is independent as to the number of cylinders, excepting as regards the necessary electric power to operate the motor to overcome its natural resistance, due to friction and compression. Electrical starters, and all others, assume the sequence of the necessary motor functions. Their limitation as a cranking device is the battery capacity.

All ignition starters are better on four than six-cylinder motors, due to the compression resistance, friction resistance, and mainly the fact that only one cylinder produces an impulse. This one impulse in a six-cylinder motor must overcome the resistance of five cylinders, while with a four-cylinder motor, that of but three, showing as 5 is to 3 in favor of the four-cylinder motor. In cold weather, the oil being of moderate cold test exerts a considerable effort to prevent rotation, and interfere with satisfactory action.

Gas starters depend mainly upon two properties of acetylene gas. First, being of about 96 per cent of the specific gravity of air; second, that its range of inflammability is great, being from about 3½ to 85 per cent. A spark is essential for their operation. Several devices using gasoline vapor are on the market and their operation applies to gas starters equally, excepting that gasoline vapor explosibility is but from 2½ to 4½ per cent. The mixture of acetylene gas and air in the cylinder is either obtained by the motor suction upon stopping, a hand pump injector to the cylinders, or the gas tank contents through a distributor valve are admitted directly to the cylinder. To start, it must be assumed that the crank shaft is not on dead center, that the ignition is in range to produce a spark in the cylinder ready to fire, and that the administered mixture will reach the plug, producing a turning effort sufficient to rotate the motor until it picks up its natural cycle.

Several gas starters have proved very satisfactory, but generally are not in the class with the kinetic devices, particularly if the latter type is augmented by a more suitable fluid than commercial gasoline.

All *ignition* or *potential* starters depend upon "starting on the spark", so frequently termed "starting on compression". A motor having the faculty of starting on the spark will do it equally well if, before attempting the operation, the pet cocks are opened so as to entirely relieve all compression in the cylinders.

The complication, multiplicity of parts and mental concentration necessary to the operation of some starters really makes one wonder whether, after all, the means warrant the end attained.

Discussion

MR. SOUTHER:—

Gentlemen, it is a great pleasure for me to come here and appear before a body of engineers who are taking hold of a subject as you have tonight.

My only criticism is that you have undertaken a great deal in the subjects you have chosen for discussion. Any one of them would occupy a day for discussion at one of the regular meetings of the Society of Automobile Engineers. There is much food for thought and discussion and a great deal of practical interest to maker, user and all-around practical engineer.

It is a privilege to be alive just now and watch the evolution of what is miscalled the valveless motor. During the last 25 years, more or less, we have all become used to the idiosyncrasies of the poppet-valve, just as we have to those of a horse. If a horse kicks or bites, we dodge and say nothing, and if a poppet-valve motor does something irregular, we say nothing. We have become used to such things.

A change is coming and I think I may say that it has come. Positive operation is possible with the non-poppet-valve motor. In addition, extreme quietness is assured.

Quietness must follow any construction where the number of reciprocating parts is small. With the Knight form of engine, so well described by Mr. Sterling, the noise from reciprocating parts is minimized.

With the single rotating valve, spoken of by Mr. Sterling, Darracq, and with the Mead twin rotary valves, also mentioned, there are no reciprocating parts used in connection with the valve operation and this is a step in advance over any other form of valve operating mechanism. Whether the rotating valve is the ultimate valve is still a question which only time can answer and very likely the public also will have something to say about it.

The question of power is well worth considering. The poppet-valve is limited in its power, largely by the inertia of the rapidly reciprocating parts. The positive rotating valve or the positive sliding sleeve is not limited in power, as the inertia is positively overcome instead of being partly overcome by cam and spring. Right here there is something for our engineers to think about.

With the poppet-valve motor the crank case and co-operating parts need only be designed to take care of speeds and powers up to 1,500 revolutions per minute, more or less. Beyond this the power developed by the poppet-valve motor begins to drop off, except with motors of special design. On the contrary, the positively controlled valve engine must be designed to take care of much greater horsepower, because the horsepower increases as a function of the speed up to unusual speeds of 2,000 to 2,500 revolutions per minute. Some crank cases with which I have come in contact, have not been designed in this way and have promptly kicked themselves to pieces at high speed. This is not to be wondered at when it is considered that the normal horsepower output of the engine is considered to be 25 and the actual horsepower output at 1,700 or 1,800 revolutions per minute was actually 40.

Mr. Sterling raised one point about the Knight sleeve valve and stated that it is tight. It seems to have proven itself tight. This must be true, inasmuch as the Knight engine develops the horsepower at all speeds, either high or low. If there were any serious leak, these valves would not do so.

Mr. Anderson raised the point that pet cocks could be opened and make very little difference in the speed of an engine. This is true and is important as indicating that it takes considerable time for a gas to pass through any aperture at high speed.

The question of the tightness of the Mead twin rotary valve

has been raised. In considering this, it must be remembered that these valves fit the bore in which they rotate, with only three-fourths of one-thousandth of an inch between the walls of the bore and the surface of the valve and that this space is filled with oil. The interval of time between cycles, even with the slow speed of cranking a motor, is very short and the oil film around a rotary valve is not broken down. At higher speeds, therefore, it does not break down.

It is clear from the horsepower curves that there is no such leakage, inasmuch as if produced to zero r. p. m., the horsepower curve intersects zero very closely, thus showing no leakage.

In connection with the poppet-valve we have become accustomed to considering the leakage around such a valve, where the contact between valve and seat is only a narrow surface and this surface one which can have no oil on it.

All this must be forgotten in connection with the consideration of a lubricated valve with considerable surface in contact.

A great many new thoughts have got to be considered in connection with this motor development.

There is much more that might be said as to the evolution of these motors; about horsepower, valve timings, valve openings, the length of time the valves remain open, etc., but it may all be briefly stated by saying that with any of these valves it is quite possible to give sufficient opening area for any horsepower that the engine is capable of developing and that the limitations are not as great as with the poppet-valve.

The shape of the cam in a poppet-valve engine has been a subject of endless study. In fact, it is still quite possible to get up an active discussion on that subject any time that a half dozen engineers get together.

Rotating valves on the contrary can be most accurately designed, timed and controlled.

AUTOMOBILE MOTORS

American Machinist, 33:483-7, 574-9, 864-7, Sept. 15, Nov. 10, 1910.—Automobile Engine Proportions, by A. G. Kessler and G. W. Lewis. Series of articles based on the average practice of the best manufacturers in the United States.

Automobile, 24:28, Jan. 5, 1911.—Flexibility of Motors. The horsepower rating of a motor should not be considered as of first importance—flexibility must have a prominent place in the final sum-up.

————24:35-40, Jan. 5, 1911.—Power Calculation for Motors, by W. D. Ennis. Suggests a method for determining the (water-cooled) cylinder dimensions suitable for required service regardless of horsepower rating.

————24:263-73, Jan. 26, 1911.—Technical Review of Motors. Review of development, discussing types and features of design.

————24:1264-6, June 8, 1911.—The Speed of Reciprocating Engines. First installment of an article by J. L. Napier reprinted from the *Automobile Engineer*, London. Considers the limitations of speed and the factors which influence it.

————24:1345-8, June 15, 1911.—Vibration in Gasoline Motors, by A. Cattanes. Discusses motor balance and disturbing moments, analyzing conditions in a four-cycle engine.

————July 6, 1911.—The Coming of the Silent Motor, by T. J. Fay. First of a series of articles dealing with motor problems, particularly with other than poppet valves.

————Aug. 3, 1911.—Cooling and Efficiency.—Considers advantages and disadvantages of present motors, offering suggestions for improving their efficiency. From *La Tech. Auto*, et Aerienne.

————Nov. 9, 1911.—The Long-Stroke Motor for Cars, by W. D. Ennis. Explains why they need re-designing and urges the standardizing of the r. p. m. of the crank shaft rather than the piston speed in estimating the horsepower.

Batey, John, The Motor Car and Its Engine, 1908.—621.3-135.

Cyclopedia of Automobile Engineering, 1909, v. 2, p. 185-238. Direct Current Motors, by Louis Derr. 621.3-C99.

Engineering, 90:555-6, Oct. 21, 1910.—Fast Versus Slow Speed Motors for Cars. Discusses the merits of the two classes of engines.

Homans, J. E., Motors for Electric Vehicles; and, Practical Points on Motor Troubles. In his self-propelled vehicles, 1908. P. 421-36.

Horseless Age, 25:9-11, Jan. 5, 1910.—Simplicity the Keynote of Engine Design, by C. S. Ricker. Illustrated review of the tendencies in design exhibited in the motors shown at the London and New York exhibitions.

Schmidt, O. C., ed., Principles of Explosion Motors; and, Electric Vehicles. In his practical treatise on automobiles, 1911. 621.3-Sch5.

White, T. H., Petrol Motors and Motor Cars. Ed. 2, 1904. 621.4-93.

Society Notes

MINUTES OF MEETINGS

Feb. 13, 1912.

Regular meeting called to order by President Roberts at 7:45 P. M. Present about 80 members and guests.

Minutes of Jan. 9 and 24 read and approved.

Report of tellers showed the election of the entire membership ballot. (List of names in minutes of Jan. 9, 1912.)

A motion was made by Mr. Fernald to have a transfer of $700.00 made from the Permanent Fund of the Society to the Commercial Account, and vote was taken in favor of passing this to letter ballot, as provided by the Constitution.

Applications for membership were received and passed to letter ballot, as follows:

For active members:—

Virgil D. Allen	Henry R. Hadlow
Frank G. Anderson	Eugene Handler
Eustace E. Blundell	George R. Harris
Willard Brown	George W. H. Helling
Walter N. Crafts	Russell T. Kingsford
Max W. Garnett	Wm. J. Ralston

Elverton W. Weaver

For associate members:—

William A. Armstrong   Arthur W. Gilson

Mortimer E. Cooley, Dean, Department of Engineering, University of Michigan, delivered an address on "Public Utilities and Their Relation to the Public". A discussion followed, in which the following persons took part: Messrs. Abbott, Paul, Roberts, Himes.

A vote of thanks was extended to Dr. Cooley.

Adjourned.

F. W. Ballard,
Secretary.

Feb. 27, 1912.

Special meeting called to order by Vice President Fernald at 7:45 P. M. Present about 65 members and guests.

Instead of the paper by Prof. J. F. Barker on "Technical Education", scheduled for this meeting, Mr. W. P. Blair, Secretary of the National Paving Brick Manufacturers' Association, gave an illustrated talk on "Some Feautres in Connection with Street Paving". Through inability of Prof. Barker to be present, Mr. Blair consented to give his address at this time.

A vote of thanks was tendered Mr. Blair.

Adjourned.

F. W. Ballard,
Secretary.

March 12, 1912.

Regular meeting called to order by President Roberts at 7:45 P. M. Present about 75 members and guests.

Minutes of Feb. 13 and 27 read and approved.

Report of tellers showed the election of the entire membership ballot (list of names in minutes of Feb. 13, 1912); also the approval of the

transfer of $700.00 from the permanent fund of the Society to the commercial account.

Applications for membership were received and passed to letter ballot, as follows:

For active members:—

August J. Bohrer — Ben F. Hopkins
John B. Day — Ernest E. Howell
Frank L. Sessions

For associate members:—

Elbridge G. Dyer — Lester L. Stoffel

For corresponding member:—

Frank N. Claflin

The President announced that Mr. Charles W. Wason had presented to the library the "Transaction of the American Institute of Electrical Engineers from 1893 to Date", and upon motion, duly seconded, a vote of thanks was extended to Mr. Wason for his gift.

An illustrated paper was presented by Mr. C. Eugene Pettibone, Safety Inspector, Pickands, Mather & Co., on "Safety as Applied to Engineering", following which Mr. Beyer, Safety Inspector of the American Steel & Wire Co., supplemented this paper with an illustrated talk. A lively discussion ensued, in which the following persons participated: Messrs. Himes, Carman, Melendy, Luckiesh, Bach and Roberts.

A vote of thanks was extended to the principal speakers of the evening.

Adjourned.

G. S. Black,
Acting Secretary.

March 23, 1912.

Special meeting called to order by President Roberts at 7:45 p. m. Present about 200 members and guests.

The subject for the evening, "A Symposium on the Automobile Motor", was taken up as follows:

"The Long-Stroke Motor", by J. B. Entz, of the White Co.

"Valve Mechanisms", by James G. Sterling, of the B. F. Stearns Co.

"Motor-Starting Devices", by H. B. Anderson, of the Winton Motor Carriage Co.

Following the presentation of these papers, Mr. Henry Souther, of the Meade Engine Co., Dayton, O., gave a short discussion on the subject.

A vote of thanks was tendered the speakers.

Adjourned.

G. S. Black,
Acting Secretary.

April 9, 1912.

Regular meeting called to order by Past President Frazier at 7:45 p. m. Present about 225 members and guests.

Minutes of March 12 and 23 read and approved.

Report of the tellers showed the election of the entire membership ballot (list of names in minutes March 12, 1912).

Applications for membership were received and passed to the Society for letter ballot as follows:

For active members:—

Glenn B. Carman — Henry W. Petersen
Otto Konigslow, Jr. — Herbert V. Schiefer
Edwin Nesbit — Harry F. Stratton

For associate member:—

Eugene R. Seiter

As required by the Constitution, due notice having been given to the members, a Nominating Committee was appointed as follows:

Mr. David Gaehr, *Chairman*	Mr. Willard Beahan
Mr. F. C. Osborn	Mr. Harry Fuller
Mr. J. H. Herron	Prof. J. F. Barker
	Mr. C. W. Hopkinson

Mr. Herron moved that the ballot be closed and the above list of names be appointed by acclamation. The motion was seconded and carried.

The program consisted of a series of papers on "The Elimination of Grade Crossings", as follows:

"Elimination of Grade Crossings from the City Standpoint", by Robert Hoffmann, City Engineer.

"Elimination of Grade Crossings from the Railroad Standpoint", by Albert J. Himes, Engineer of Grade Elimination, N. Y., C. & St. L. R. R. In Mr. Himes' absence, his paper was presented by L. V. Gaylord and G. H. Tinker.

"Embellishment of Railroad Crossings", by Frederick W. Striebinger, Architect.

After a short general discussion, meeting adjourned.

F. W. Ballard,
Secretary.

April 23, 1912.

Special meeting called to order by President Roberts at 7:45 p. m. Present about 150 members and guests.

The President introduced the speaker, Mr. Robert R. Abbott, Metallurgical Engineer of the Peerless Motor Car Co., who presented an illustrated paper on "Steel and Its Heat Treatment".

Following the presentation of the paper, a lively general discussion ensued, which consisted largely of questions by members and visitors, and answers by Mr. Abbott.

A vote of thanks was tendered the speaker.

G. S. Black,
Acting Secretary.

Smoke Abatement Committee

During the past ten years the City of Cleveland has made various spasmodic efforts to lessen the smoke nuisance. Nothing of very lasting benefit has been accomplished, due partly to the political and civic uncertainties, and to the lack of any adequate smoke ordinance.

One of these causes for inefficiency has been removed, as a new ordinance was passed by the council, in January of this year, and it is in the hope that we may minimize the general evils inherent to a municipal system of handling the smoke abatement, and of being prepared to report to the Society the status of the situation from time to time, as well as to disseminate valuable information on the subject, through the JOURNAL and other means, that this committee has been formed.

We believe that, in order to accomplish the best results in smoke abatement, the various new furnaces now being installed should be so designed as to minimize the smoke given off. This plan, if carried out, will give a smokeless city as soon as the offending furnaces now in use have outlived their usefulness.

Local conditions vary, and all engineers are aware of the great variety of results which may be obtained by slight alterations in furnace designs. We realize, therefore, that existing conditions must be studied and exact and thoroughly investigated data obtained before any final recommendations can be made with authority.

As very little information is available which applies to Cleveland conditions, this committee considers that its first duty will be to collect and compile reliable data which will be of use to Cleveland furnace owners and designers. This will be published from time to time in the JOURNAL by the Smoke Abatement Committee, and we shall appreciate and urgently solicit any aid which the members can give us in collecting this data.

We shall be glad to give our advice to any furnace owner or builder, either about new work or proposed changes to furnaces now in use.

Tell us of your furnace troubles, and it may prove mutually beneficial.

WM. M. FABER,
Chairman
F. W. BALLARD
R. H. FERNALD
DAVID GAEHR
F. M. KINSLEY
T. A. LAWES
E. H. WHITLOCK

This department is for the use of members desiring positions or requiring engineering services; it is under the personal direction of the secretary, who is anxious to increase its value to the members. Therefore, if you are in need of engineering help, or desire to secure a position, do not hesitate to call on the department for assistance.

All information is handled confidentially.

MEN AVAILABLE.

20A—Mechanical engineer; graduate Rhode Island Technical School; extensive experience in special machinery and small tools; desires position as superintendent or mechanical engineer.

21A—Mechanical engineer; graduate of Case School of Applied Science; desires position with consulting engineer in power plant work.

22A—Civil engineer; desires position as concrete inspector, or on general construction work.

23A—Mechanical engineer; graduate Case School of Applied Science; eight years in general automobile work—testing, drafting, repairing, etc.; also considerable experience designing special machinery.

24A—Mechanical engineer; general mechanical experience, car design and signal work, construction in concrete and steel, shop methods and costs; desires position as mechanical engineer or assistant to superintendent.

25A—Mechanical engineer; shop experience seven years; designing cranes and hoists three years; designing pumping and hoisting engines seven years; engineer in charge of maintenance of plant, tools, etc., four years; superintendent on high-grade lithograph presses five years; desires position as superintendent.

26A—Mechanical engineer; experienced in coal and ore handling machinery as draftsman and designer; desires position along similar lines.

27A—Electrical engineer; three years in testing department of G. E. Co., and six years in charge of gas producers, electrical equipment, boilers, turbines, engines and manufacturing department of large plant; familiar with bonus system and labor saving management.

No. 28A. Mechanical engineer; Case School graduate 1911; age 23; American; single. Taught kinematics Washington University; also experimental laboratory work; machine shop experience; desires position in power plant.

OUR ADVERTISERS

ALL HAVE SOMETHING TO SAY THAT SHOULD INTEREST ENGINEERS. READ IT, AND THEN WHEN YOU ACT ON IT, TELL THEM THAT YOU SAW IT IN THE

JOURNAL